Engineering Record

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Problem of Sea Defenses

COAST erosion and sea defenses are engineering subjects of much more prominence abroad than in the United States. This is probably due to more frequent encroachment there by man on the foreshore, and higher values of shore property. That the subjects will need more attention in this country is evident from the recent experiences at Los Angeles, at one end of the country, and at Seabright, N. J., at the other. The destruction was the greater at Seabright, where damage amounting to about $1,000,000 was caused to shore property by two storms coming a week apart. English engineers have amassed a great deal of experience along these lines, and it is not amiss to direct the attention of American engineers to it.

Grand Trunk Pacific

CANADA has carried the palm for some time in extensive railway construction, but the larger projects are now approaching completion. The most notable of these, and one that ranks among the greatest of railroad achievements, is the Grand Trunk Pacific, projected through what was generally regarded, until a few years ago, as the frozen North. If the present rate of progress is continued May 1 of this year will see the last spike driven in the new transcontinental line. Steel is to be laid into Prince George, it is expected, by Jan. 10, and a gap of only 106 miles will then separate the approaching railheads. Construction has been advancing at the rate of 3 miles a day (1½ miles daily on each of the approaching ends), and it is believed that tracklaying can be continued through the winter. Thus far climatic conditions have been reported as exceptionally favorable to fast work. On the Western division trains have been operating as far as 360 miles east of Prince Rupert, the Pacific terminus, while the railhead being advanced from the east was about 1225 miles west of Winnipeg on Dec. 20. A roundhouse has been completed and general good progress made in providing divisional facilities at McBride, 125 miles east of Prince George, and operating equipment is now being collected at Vancouver for early shipment to the western end of the line. If hopes are fulfilled, May 1 may very properly be set down as a great day in the annals of the Canadian West.

Lowering the Disaster Curve

WILL exit disasters, as at Calumet, platform tragedies, as at Long Beach, Dayton flood losses, lodging-house fires, as at Boston, and Cedar Rapids concrete-building failures be duplicated in 1914? The Engineering Record has no intention of harrowing the reader's feelings by recounting the details of these horrors, but this seems an appropriate time for engineers and constructors, municipal officials and all those responsible for structures to realize fully their responsibilities and so modify or inspire their organizations that the year 1914 shall present a better record than its immediate predecessor. The means of preventing disasters in each of the classes noted above are well known. The problem is to see clearly where the necessary remedies must be applied. Certainly the dimensions of exits do not longer lend themselves to discussion, nor are data lacking as to the effect of freezing temperatures on concrete. While there is more latitude for judgment on flood prevention measures—and the best of a number of feasible alternative schemes in a given case can only be determined after careful study—it is nothing short of criminal to allow financial considerations to stand in the way when competent engineers have picked out the best plan. Spineless administrations are equally guilty when they fail to force compliance with building laws. Good can be drawn from evil if each engineer and each municipal official will inquire whether the fire, panic, flood and structural-failure horrors above enumerated can occur in works under his jurisdiction. If such consideration results in activity in every city in the country comparable to that manifested where the disasters occurred, the failure curve will drop during the present year.

Efficiency of Typhoid Vaccine

SOME months ago attention was called in these columns to the efforts being made by the U. S. Reclamation Service to eradicate typhoid by the use of vaccine. That the efficacy of such treatment has been all that the physicians have claimed for it was established beyond serious doubt some years ago; but the record of its use in the army and the navy during the last year is so remarkable that it is worthy of special notice. This record deserves particular emphasis in an engineering journal, for typhoid is the chief of the water-borne diseases. The army got through the year with only two cases in the enlisted force of more than 80,000 officers and men. Of the two cases, one was that of a man who had not been treated with the vaccine; the other was among the troops in China. This man had been immunized in 1911, but the history of the case is in doubt. Before the vaccine treatment was adopted the typhoid average was three per 1000; in 1910, before inoculation was practised, the rate was 2.32 per 1000; in 1911 it dropped to 0.80, and in 1912 to 0.26. The navy's record is not so good, due, it is believed, to the change of food and water when on shore leave in various ports and to the comparatively recent adoption of the treatment. Nevertheless the total number of cases for the year ended last June was only seven—among 50,000 men. Four of these were treated at a remote tropical station, where the vaccine had deteriorated. These cases, moreover, were mild and convalescence was rapid. As comparison it may be noted that the rate as late as 1911 was 3.61 per 1000. These are plain indications that typhoid as a scourge is going the way of smallpox and other dread diseases. The constant improvement in the protection of water and milk supplies, and the quick application of vaccine where danger is found are tending to lessen its prevalence in the community at large.

Engineer on Utilities Board

ENGINEERS can have nothing but praise for the Governor of Illinois in appointing one of their number a member of the newly organized Public Utilities Commission. But, if his Excellency is correctly quoted, he has not caught the spirit of the argument of the engineers in urging such appointment. He is quoted as saying: "I have named a judge, a lawyer who is a former Governor, a business man, a farmer and a civil engineer. I was asked to name a representative of the labor unions, a representative of the coal men, one representing the railroads, besides others representing various other interests affected by the utility law. I found I did not have enough places to go around, so I named men of general, all-around ability." The engineers have argued neither for representatives of special interests nor for all-around men, but for appointees of special fitness. That the argument is, however, appreciated in some quarters is evident from comments on the Governor's appointments in the Chicago "Record-Herald" and the Chicago "Daily News." The "Record-Herald" says: "The board as a whole may be called respectable, but it is singularly deficient in special fitness"; while the "News" declares that "of the four appointments . . . only one can be justified on the ground of demonstrated fitness for the duties to be performed. That is the appointment of W. A. Shaw, former assistant city engineer." Special fitness does not mean, of course, that engineers alone are properly eligible for public-service commissionerships. There are economists who know much about rate-making, evaluation and kindred subjects. There are lawyers who have given special attention to the growth of corporation and public relations of utilities. There are business men who have had wide experience in financing and who appreciate the difficulties of conducting a large business, and —dare it be said publicly?—there are railway-traffic officials who could render invaluable public service on utility boards. There are men aplenty with special fitness for regulatory work. Persistence in the educational campaign will impress this fact more and more on public officials and will result in more frequent recognition of the sort so happily awarded the engineering profession by the Governor of Illinois.

Notable Hydroelectric Plant

IT is difficult to characterize properly the construction work carried out by Stone & Webster at the Big Creek development, described on page 47, without dropping measured, dispassionate phrases and using the language of romance. One is tempted to say that the age of giants is not yet past, though the giants are masquerading under the guise of engineers.

The difficulties of transportation alone would have been sufficient to appall the weak-kneed. The site was so far removed from the nearest railroad that the plant could not have been finished in time to impound water in 1913 had team haulage been depended upon. The engineers, therefore, constructed a railroad than which none seemed more sinuous to a representative of this journal as he rode behind two Shea engines laboring under the load of a six-car train on which the trip to Cascada was made. Looking down the 75 per cent grades of the inclines was only less terrifying than a view of the sidewalk from the cornice of a thirty-story building. All about were other and steeper slopes, and continually higher elevations. Some of the inclines were a mile long. The security of the cars was insured by special bridles, and safety was further promoted by locating the lower end of the line away from the camp and structures.

Labor problems, in maintaining a dozen camps, involved unusual difficulties, due not only to the character of the work but also to the altitude. The separation of camps for tunnel drivers from quarters housing men working on top is a small thing, but time-consuming friction was thereby avoided. That many laborers could not stand the extreme altitude at which the dams and upper tunnel were constructed is not to be denied. However, "altitude sickness" became particularly noticeable when the more pleasant power-house work began at a point a mile below in elevation.

Of the more interesting features of the work may be noted the elaborate trestle at dam 1, housing bins and twelve mixers and affording a bridge over which material was transported to the other dams. It is believed, too, that the inclines operated with electric mine hoists were steeper than any heretofore attempted. Pipe laying with the "go-devil" proved efficient and rapid. Here as in other Western penstocks carrying water under extremely high heads, imported lap-welded pipes were used at the lower end, and the lines were reduced in size and finally bifurcated as the limit in thickness of plates was reached.

These construction features, while most interesting, should not be allowed, however, to overshadow the technical features of the plant. These have already been treated briefly in this journal (Sept. 14, 1912, page 287). An unusual wheel arrangement has been used. The nozzles are stationary and controlled by needle valves. There are two independent oil-pressure governors, each controlling a single wheel and so arranged that either wheel of the unit can be worked quite independently so that partial loads may be handled with the greatest possible hydraulic efficiency. In addition, each governor operates a relief valve to take care of excessive rise of pressure in the pipe line. The bearings which carry the wheels and rotor are of unusual construction, with hollow-forged steel shafts 20 in. in diameter resting in water-cooled babbitted bearings 5 ft. long, being lubricated with auxiliary pressure-oil supply. The exciters are planned for either motor or impulse-wheel drive. Notice of the unusual transmission line by which the power is carried to Los Angeles, 240 miles away, at 135,000 volts (to be increased to 150,000) is taken in another editorial in this issue.

Whether from the designing or construction standpoint the Big Creek plant is notable and reflects much credit upon its builders.

Another Record Shattered

ANOTHER record has been broken. This time it is in volume of masonry placed in a dam during one month. The new mark —53,240 cu. yd. of cyclopean masonry and concrete blocks in twenty-five eight-hour days—was established at the Kensico Dam on the Catskill Aqueduct system. The figures given by Mr. George T. Seabury in the leading article of this issue indicate a maximum placement of 2250 cu. yd. in a single day and a daily average of 2130 cu. yd. for the twenty-five working days from Aug. 25 to Sept. 24—a most enviable performance. The most dangerous contenders for the position occupied by the contractors on the Kensico work are the builders of the Lake Spaulding dam in California, and the Arrowrock dam of the U. S. Reclamation Service. At Lake Spauling the best monthly record (thirty-one working days) has been 40,485 cu. yd.; the best day's run, 2150 cu. yd., and the average daily yardage, 1306. At Arrowrock 38,456 cu. yd. of masonry were placed in August, 1913 (twenty-six working days); the best day's run was 1600 cu. yd., and the average daily run for the month, 1480 cu. yd.

After the Kensico figures have been digested it is natural to inquire as to the construction methods and plant equipment responsible for this performance. These questions are fully answered in Mr. Seabury's article. The masonry is placed by traveling derricks on temporary elevated tracks. These traveler tracks were carried on concrete piers, which are embedded in the dam. As construction progresses new piers are erected and the travelers raised to higher working levels in lifts of 20 ft. or more.

Another of the interesting construction features is the method of molding the concrete blocks with which the structure is being faced. Mixers, mounted on a traveler, pass directly over the block forms, into which concrete is deposited directly, without the use of buckets or cranes. Taken all in all, the work is a good example of what can be accomplished when both the planning and the execution of work are well handled. Team work counts just as much —or more—in building huge engineering structures as it does on the football gridiron.

New Conceptions of Boiler Practice

CLOSE observers of power-plant practice have long known that the boiler room is the most important and most neglected portion of the average steam-producing installation. Visitors to generating stations reflect this neglect in their haste to escape from the heat and dirt associated with the majority of boiler rooms, and even operating engineers, with rare exceptions, are inclined to favor the comparatively clean duties of the turbine or engine room. The results have been no more than could be expected; but a new day is dawning for the boiler plant, and in many progressive power-producing installations a scientific effort is being made to better conditions, with a disregard of personal comfort on the part of executives which bodes well for the future. Witness the thoroughness of organization found in the great central stations, in the power plants of the electrified railroads terminating at New York City, in the stations of metropolitan traction systems—an organization which covers the duties of coal passer, water tender and conveyor maintainer with as much exactness as it determines the responsibilities of the watch engineer and the load dispatcher. The adoption of calorimeter tests of fuel, the improvement of boiler room records, the conducting of boiler performance tests, the measurement of steam flow, the checking of water and coal consumption through shorter time periods, the installation of load indicators, the supervision of stoker and blower speeds, the control of draft and inspection of fires have placed boiler-room practice on an entirely different plane from what it held a few years ago. The pursuit of the elusive heat unit grows keener, and refined methods of boiler-room engineering are coming to the front.

In the December issue of the "Journal" of the American Society of Mechanical Engineers, this new conception of boiler practice is well illustrated in an article by Walter N. Polakov upon "Task-Setting for Firemen." The author exhaustively discusses the application of the Grinevetski method of graphical analysis to a Pennsylvania central station, reviews the variable factors and constant quantities affecting operating economy, sets forth test data and points out their application to the routine work of firing and draft control. In addition he discusses the influence of physical surroundings upon the efficiency of firemen, and co-ordinates in an unusually interesting manner the mathematical and operative phases of steam production. To describe the analysis of the factors involved in the plant selected would require an extended abstract of the paper; but in rising from its perusal two striking lessons may be drawn. The first is the desirability of specialized knowledge in testing and interpreting boiler performance; the second is an appreciation of the splendid results which may be secured merely by applying deductions from test data to routine service, and even without any additional equipment investment, except for a few instruments for the guidance of the firemen in their work of living up to their instruction cards.

The limitations of the average boiler test are much greater than most people realize and a thoroughly scientific study of combustion involves factors usually neglected or lumped together in a general mass of data. The author expresses these views in the statement that a mere heat balance is unable to answer many important questions bearing upon economical steam generation. Lack of positive, well-grounded principles is repeatedly responsible for faulty construction of furnaces and arrangement of baffles and gas passages. More light is needed in many tests upon such questions as the variation in specific heat of gases, in radiation of furnace, in efficiency of heat transmission, in volume of gases in passages with different combustion conditions, and in percentage of filtration of air at various rates of firing. For the purpose of setting definite standards, it is imperative in the author's opinion to conduct a number of observations, though of short duration, dealing in each case with one and only one variable in order to find its limiting effects. From these investigations spring the graphic analyses which may be applied directly to the concrete task of improving combustion practice and of maintaining the maximum commercial efficiency of each particular plant—a task for the expert engineer instead of for the young college graduate frequently entrusted with such responsibilities.

Given the specialized analysis of boiler-plant conditions above hinted at, the daily practice of the most efficient methods becomes absorbing and feasible. Specifically, the ordinary steam gauge and water column, which usually constitute the total measuring equipment of each boiler, are supplemented by an indicating steam meter, draft gage and an indicator for the co-ordination of the condition of firing with the load momentarily carried by each boiler. By the calibration of the steam-flow meter to indicate to the fireman the required thickness of fuel bed, corresponding to the number of pounds of steam drawn from the boiler, and the draft necessary and sufficient to supply the required amount of air for combustion at a rate called for by the indicated steam demand, a means of obtaining skilful boiler control is provided. Frequency of coaling is made a function of the feed-water rate and a bonus system based upon simple and inexpensive clerical records, analyzed by a special slide rule, insures the co-operation of the firemen. The work of the latter is passed upon in shifts, which encourages team-play and obviates individual jealousies. By analyzing the results of each shift's work before it returns to duty again and presenting the results to the operating force, interest is sustained.

By no means the least factors in scientific boiler management are the provision of comfortable chairs with backs (a small point which cut the fire cleaning period from 24 to 18 minutes per 100 sq. ft. of grate area in the case cited by the author), good drinking water, adequate ventilation, and decent illumination. There is no reason to doubt that the good results obtained at Warrior Ridge can be duplicated elsewhere by the application of these methods and there is no question that a new impetus is given by such work to the achievement of larger economies in power plant operation.

Progress in Electric-Power Transmission

THE last year was notable for the initiation of several very remarkable transmission plants and a general tendency toward higher voltages than has been apparent for the half dozen previous years. The march of advance in voltage has been an interesting one, taking place in a series of rushes separated by intervals of rest. After the first break from low voltage up past 10,000, progress was very rapid, until about 40,000 volts was reached, and with it came some rather startling phenomena indicating the failure of the air as a dielectric. A brief period of investigation showed that the coronal discharge was not to be feared under ordinary working conditions, and the pressure accordingly rose rapidly to 60,000 volts or thereabouts, at which it stuck persistently for some time. The trouble at this point was the difficulty of making insulators of the ordinary type with a sufficient factor of safety. It is an extremely troublesome matter to get a pin-type insulator which will stand materially over 100,000 volts in a drizzle, let alone the 120,000 which would be required for a factor of safety of 2—certainly the smallest that due caution would require.

The invention of the suspension insulator cleared the way for further advance. Lines at 60,000 or 70,000 volts could then be given a much better factor of safety, and 100,000 was very quickly reached. At from 100,000 to 110,000 volts the top-most working pressure has stuck until the last year. The number of plants working at 100,000 volts, even in rather severe climates, became sufficient to establish transmission at such voltage on secure ground, and near the end of 1913 the first upward jump on a commercial scale was taken in the notable transmission from Big Creek, Cal., to Los Angeles, 240 miles, at an initial pressure of 135,000 volts, to be raised toward 150,000 as the load demands. The construction of this installation is described in this issue. This, by the way, is the longest regular commercial transmission yet attempted, and in spite of distance and extreme voltage there is no reason to anticipate anything but successful working. On these very long lines at high voltage the electrostatic capacity effect is so considerable that inductive load, cordially abominated by the average central station, becomes a welcome friend. Many of the long Western lines have gladly taken on an unusual amount of induction-motor load to compensate the line capacity, and in this Big Creek development two large synchronous machines are deliberately installed in the main substation for the same purpose. The line for this great plant is in complete duplicate, there being two lines of towers each carrying a single three-phase circuit. The wires are carried on nine disc insulators in series, on towers of moderate height spaced 660 ft. apart. The factor of safety in insulation ought to be good, for each disc of the series has been tested wet at more than 50,000 volts. Several other important plants in the West and South have gone into operation within the last few months, perhaps the most notable of all being the great Keokuk plant, transmitting power at 100,000 volts into St. Louis over a line more than 140 miles long.

The constructional features of lines in almost all the important plants at the present time are similar; steel towers with suspension insulators are used, although it should be noted that, especially on the smaller lines, there is a growing tendency toward using steel A-frames instead of quadrilateral towers—a construction often very materially cheaper and, if properly installed, no less secure. In station design there is a very gratifying disposition to work toward simplicity. It has been found that cheapness of construction and ease of operation require the use of fewer units than would have been installed a few years ago, and that, in particular, it is desirable to reduce the switching apparatus for high voltages to a very modest amount. A number of Southern and Western lines do most of the high-tension switching by air-break switches of large dimensions installed upon poles, and reduce the complication of the indoor switchboard as much as possible. One perhaps cannot eliminate high-tension oil switches altogether, but such apparatus, by proper layout of the switching system, can be greatly decreased in amount without interfering with the efficiency of the plant. Less has been heard of late about lightning than used to be the case, and one of the features responsible for this happy condition is the increasing use of grounded guard wires over the circuits and the intelligent application of the aluminum type of lightning arresters in the stations. For moderate voltage, however, reliance is placed in many plants on the simpler arresters, even of the horngap type, which are less sensitive, but somewhat more easily kept in order.

Another pleasant thing to record in connection with power transmission is the small amount of trouble given in these days by high-tension transformers. In fact, nobody seems now to worry much about what used to be the chief cause of anxiety. It is worth noting that in some of the biggest of the foreign plants the engineers have found it desirable to come to the American manufacturers for transformers, even when the rest of the plant was of home manufacture. Altogether, therefore, the recent progress in electric-power transmission has been of a very encouraging character, and even as distances increase and voltages rise there are no signs of outstanding difficulties to imperil the progress of the pioneers.

Constructing the Kensico Dam

Record Yardage of 53,240 in One Month; Cyclopean Masonry for Catskill Aqueduct Structure Is Handled by Traveling Derricks on Elevated Tracks

By GEORGE T. SEABURY
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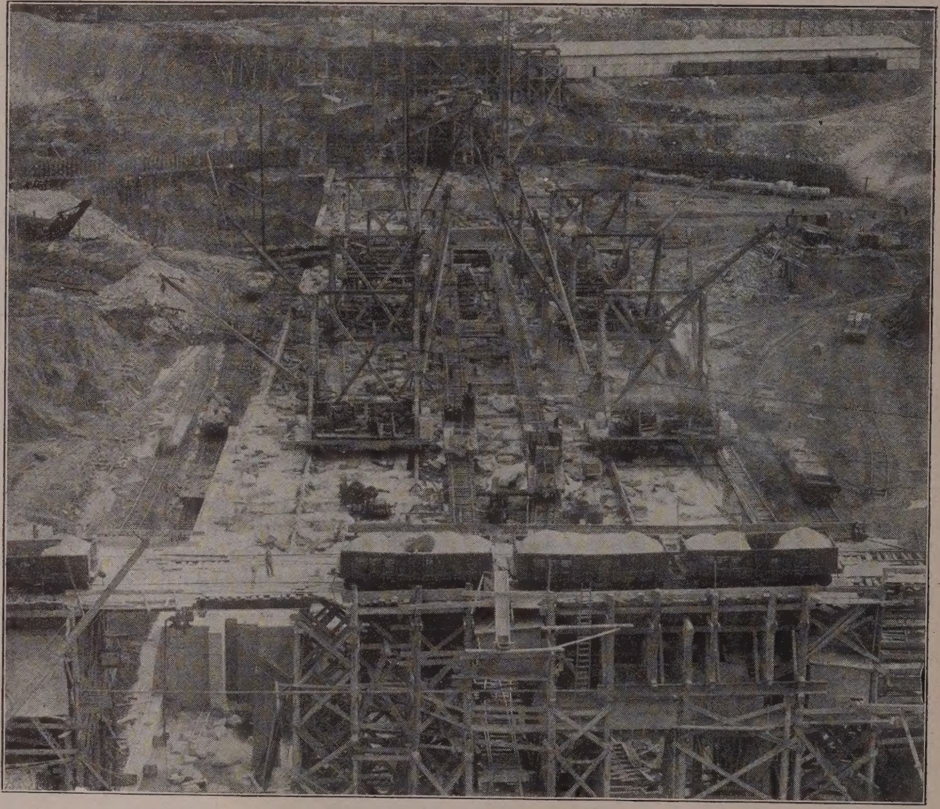
Construction, Board of Water Supply, City of New York

ALL records for volume of masonry placed in a dam on the basis of a single daily 8-hour shift have been broken at Valhalla, N. Y., on the Kensico dam of the Catskill aqueduct system for the additional water supply of New York City. In the twenty-five working days from Aug. 25, 1913, to Sept. 24, there were incorporated in the structure a total of 53,240 cu. yd. of masonry. Traveling derricks on elevated tracks, selected in preference to cableways for placing the bulk of the 900,000 cu. yd. of cyclopean masonry and concrete blocks which the completed dam will contain, are the principal construction features of the work now in progress. The traveler tracks are supported on concrete piers, which are left embedded in the dam as the masonry rises, and the tracks moved to new levels, in lifts of 20 ft. or more, as work progresses. This form of plant equipment was chosen primarily to effect the rapid placing of the large mass of masonry. On Dec. 20, less than eight months after the placing of masonry was begun, more than 316,000 cu. yd. of cyclopean masonry and concrete blocks had been incorporated in the dam by one shift working only eight hours per day.

CATSKILL SYSTEM

The development and construction of New York City's new water supply system, whereby water will be impounded in the Catskill Mountains, brought to the city in an aqueduct 92 miles in length and large enough to admit a train, and delivered to all the boroughs of the Greater City in a tunnel 17½ miles in length, lying deep in rock have furnished a number of new and striking features of design and construction. Throughout this entire work there has been apparent the creation of new ideas and new practices resulting in economy and efficiency. New marks have continuously been set in each of the types of work involved, only to be exceeded as the work has continued.

The working season now closing has seen a herculean effort in the building of Kensico dam. That structure—a gravity-type dam of cyclopean masonry, which is to be 1843 ft. in length—310 ft. in height at the maximum section—has, since April 23, 1913, been more than one-third built, so far as quantities alone are concerned.



View Looking East, Showing Layout of Travelers and Service Tracks

Between Aug. 25 and Sept. 24, in the twenty-five days worked, there were placed 49,850 cu. yd. of cyclopean masonry, 2630 cu. yd. of concrete blocks, previously made, and 760 cu. yd. of mass concrete, a total of 53,240 cu. yd., or an average of 2130 cu. yd. per day. During the same interval there were made, in addition, 4953 cu. yd. of blocks to be stored and placed later. The maximum quantity placed in any one day was 2250 cu. yd. These figures it is believed are records for eight-hour days.

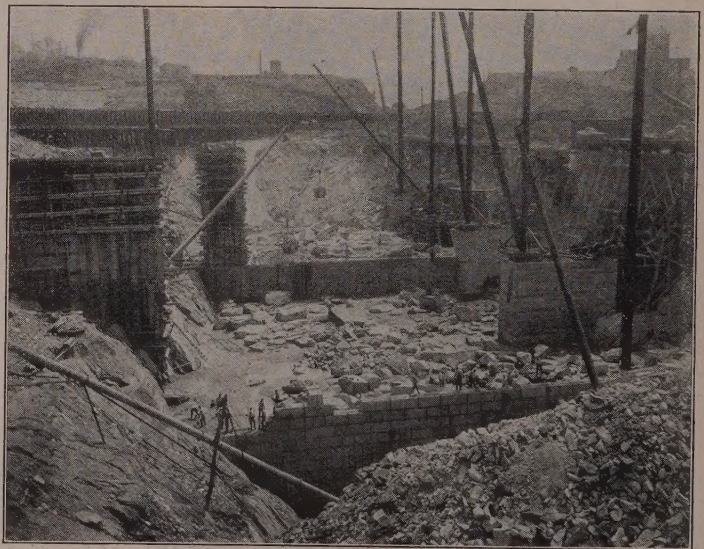
GEOLOGICAL INVESTIGATIONS

Kensico reservoir, which is to be formed by the Kensico dam, supplemented by a low dike about 1000 ft. in length, is to act as an intermediate storage reservoir and will be maintained almost entirely by the flow from the Catskill aqueduct, the water having been collected in the Catskill Mountains about 75 miles to the north.

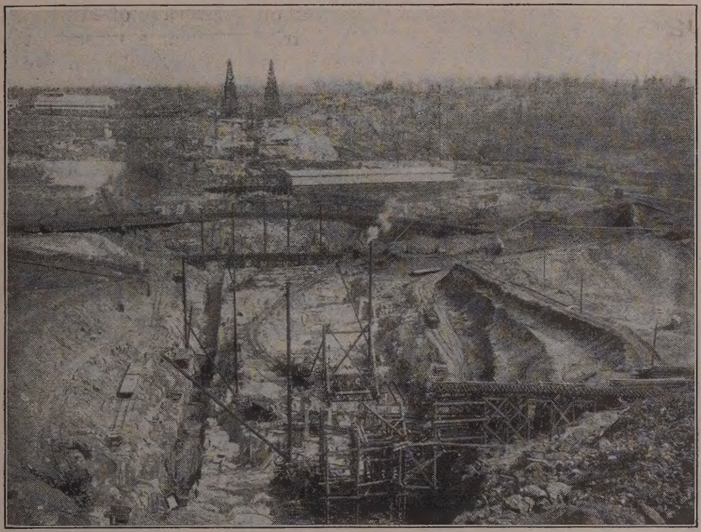
GEOLOGICAL FORMATION

The new dam site is upstream from that of the old Kensico dam, an earth

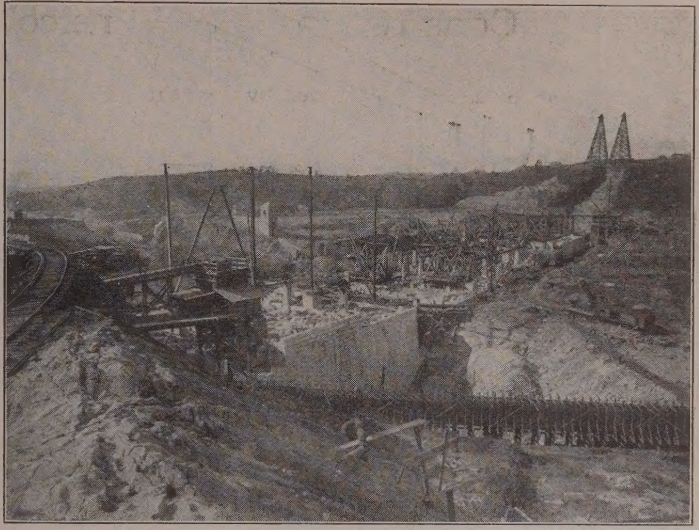
Downstream View of Gorge before Completion of Excavation



Gorge Partly Filled with Masonry—Looking Downstream



View of Dam Looking East before Placing Masonry



Appearance of Dam, Looking Upstream, on Dec. 30, 1913

structure with rubble core wall, built in 1885. Preliminary investigations were made from the surface of the water in the reservoir so formed by the Bronx River. These preliminary investigations indicated that the foundation would be of three different kinds of rock: Manhattan schist at the west end, Inwood limestone in the center, and Fordham gneiss at the east end. Both contact planes were penetrated by diamond drill borings, and it was believed that both would be tight and sound at no great distance below the rock surface.

The contact between the limestone and the gneiss was determined to be the location, as the point of least resistance, of a preglacial gorge, and the subsequent excavation revealed a deep depression. The removal of the disintegrated and unsound rock developed the contact as perfectly tight and satisfactory.

The profile of the prepared foundation consists of a slope on the west end at about 30 deg. with the horizontal; a rough but comparatively level stretch 750 ft. in length; the gorge, a V-shaped hole 250 ft. wide and 110 ft. deep; and a slope at the east end of about 25 deg. with the horizontal. It is in the middle portion of the dam site that masonry has been placed, 915 ft. of bottom having been covered, including the preglacial gorge.

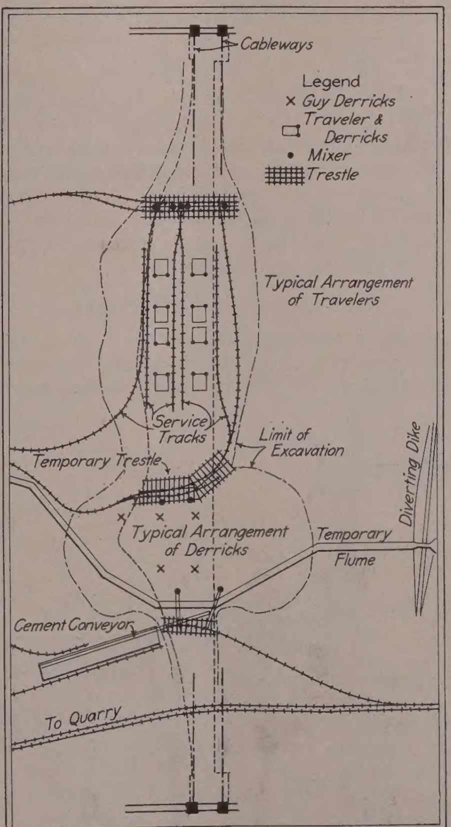
Expansion Joints

Recognizing that in a mass of masonry of this size transverse cracks will occur, the inevitable is foreseen and controlled by expansion joints at regular intervals, provided with various water stop devices which, it is believed, will prevent seepage to the front face of the structure where its appearance would be unsightly. A copper strip, continuous from the bottom to the top of the dam, is to be placed in such a way across each joint that it is expected to entirely seal it. However, should water pass these plates it will be intercepted by wells, which are to be drained by a gallery parallel to the upstream face and extending throughout the length of the dam. The flow from this gallery will be conducted to the Bronx River through a conduit constructed under the plaza in front of the dam.

Expansion joints are formed by building vertical tongue and groove walls of concrete blocks normal to the face of the dam. This wall, therefore, makes a form behind which the cyclopean masonry is placed and also permits the building of the dam in sections. When one such section is built up to a certain height the exposed face of the wall is painted with an asphalt paint and the concrete of the next section placed directly against it. The paint, by preventing adhesion, insures that the contraction which will occur will be taken care of in this plane and will not cause a crack to occur at a point where it will not be controlled.

The upstream face of the dam is also built of concrete blocks. The downstream face, up to the height at which it will be visible above the finished grading, is cast directly against rough forms. Above this elevation the face will be of cut stone.

The natural division of the foundation into a deep hole and a fairly level stretch determined the methods of the placing of the concrete; and the possibility of building this relatively long stretch of masonry of a considerable width is probably the feature that, more than anything else, has permitted the construction at such a rapid rate. The work this year has been separated into two different jobs, one dealing entirely with the gorge and the other with the remaining flat portion to the west. The materials come from the same source.



Arrangement of Mixers, Travelers and Derricks

Masonry in Gorge

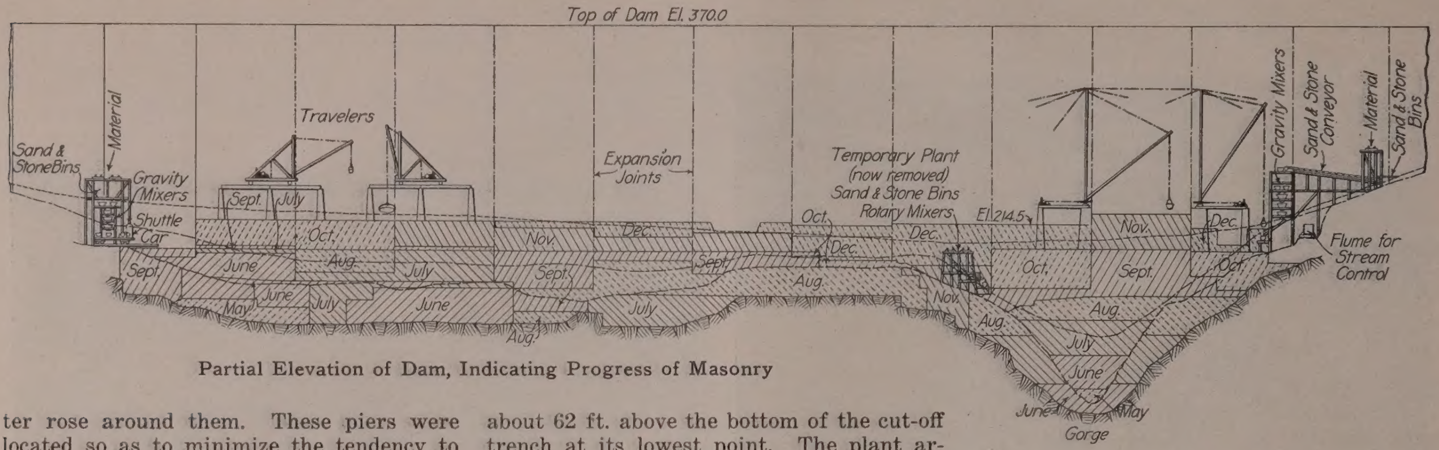
Masonry was placed in the gorge entirely by guy derricks. Their positions were changed only as the rising mass required them to be elevated or when the area became so large that it was necessary that they be clustered about one particular location at a time. When work was begun they were on the two sides of the gorge, the bottom of which was nearly 100 ft. lower than their foot blocks. Had the foundation been level at this low elevation the dam would have had a width of about 275 ft., but the sound rock rose so sharply at the downstream toe that the maximum width was only 233 ft.

The first mass of masonry placed was at the bottom of the V, about two-thirds of the distance downstream from the vertical face of the dam and between bulkheads parallel to the upstream face and only about 30 ft. apart. This was as great a length as it was practicable to keep clean and dry until the concrete had been deposited. Both bulkheads were then moved, respectively, a short distance up and down stream, and the new regions so contained were cleaned and filled with concrete, making a larger working area, which was then raised in steps of about 8 ft. in height.

When about two-thirds of the bottom had been covered progress upstream was stopped and the toe completed. This permitted that portion to be built up to a considerable height, the back being a series of steps, the general direction of which was approximately normal to the downstream face and to the line of thrust.

As soon as the cutoff trench on the line of the vertical upstream face was completely excavated, concreting was started at that point and the masonry placed in horizontal layers between the upstream face and the front portion already built. No bulkheads were used for this part where the line of thrust with reservoir empty is more nearly vertical.

Throughout this work the derricks were placed on concrete piers, which were incorporated in the mass of masonry as the lat-



Partial Elevation of Dam, Indicating Progress of Masonry

ter rose around them. These piers were located so as to minimize the tendency to produce planes which might induce cracks parallel to the upstream face of the dam. Piers supporting derricks were usually 10 x 12 ft. at the base and 10 ft. square at the top, and were connected with I-beams to piers supporting the hoists. The hoist pier was 6 ft. square at the base and 4 ft. square at the top.

On account of the elevation of the rock at the downstream toe and the long booms of the derricks, it was possible to locate some of them outside the structure and it was not necessary, therefore, to have piers where the line of thrust would strike them at a small angle. The piers varied from 20 to 40 ft. in height, the taller ones being at the lower elevations and made somewhat larger than above stated.

HANDLING OF CONCRETE

At first concrete was mixed by two 1-yd. Ransome mixers located in a trestle parallel to and on the west side of the gorge. The trestle gave access to trains providing stone, sand and cement to bins and storehouses located within the trestle and above the mixers, which were at a height of 100 ft. above the bottom of the gorge. Flat cars, loaded with large stones to be embedded in the concrete, were run onto spurs where they could be reached by the derricks.

When the concrete rose to the elevations of the rotary mixers they were superseded by two Hains-Weaver gravity mixers each of 2-yd. nominal capacity. These were located on trestles on the east side of the gorge, their bucket platforms being at a height of 135 ft. above the low point of the bottom and outside the limits of this year's work. The rotary mixers and the trestle which contained them were subsequently removed and that section was filled with masonry.

As the top of the concrete rose the area increased so that it was necessary for the derricks to pass both stone and concrete to each other, a feature that would probably have been eliminated had it not been extreme only toward the end of the working season. Five derricks were the usual number, though at one time there were six so employed.

The remaining portion of the center of the dam, which differed from the gorge in that it was more of the nature of a horizontal plane on which masonry was to be placed than of a hole which was to be filled, was built entirely from elevated tracks. The concrete was mixed at the western end, transported by shuttle cars and placed by derricks mounted on travelers. The service and traveler tracks were for the first lift all at such a height that the concrete could be brought to El. 192, an average of 27 ft. above the foundation and a maximum of about 62 ft. above the bottom of the cut-off trench at its lowest point. The plant arrangement of this portion will probably be employed for the completion of the dam, since the gorge has been brought up to the general level. All tracks are supported on concrete piers either cast in the block yard or cast in place. When this entire portion of the dam had been brought to El. 192 these tracks were raised so that the concrete could be built to El. 214.5, a rise of 22.5 ft., and a third lift to El. 239.5 is now being prepared. The traveler tracks are supported on piers 4 ft. square at the top and 6 ft. square at the base. The service tracks are on piers 1.5 ft. square at the top and 3.5 ft. square at the base. The piers are spaced 39.5 apart, a distance half that between expansion joints, and the tracks supported directly on 28 and 24-in. I-beams.

QUANTITIES OF CONCRETE PLACED IN TERMS OF BUCKETS OF 52 CUBIC FEET

Mixers

Month ending 1913	Rotary No. 4	Rotary No. 5	Gravity No. 6	Gravity No. 7	Gravity No. 8	Gravity No. 9	Gravity No. 10	Rotary No. 11 and No. 12
May 20	1,713	....	387	392	....	....	....	....
June 20	3,160	1,118	2,499	2,817	1,946	....	....	....
July 20	3,511	3,594	3,276	2,920	1,821	....	....	....
Aug. 20	3,720	3,948	4,944	4,781	2,472	732	....	....
Sept. 20	3,782	419	4,988	5,188	2,923	4,617	742	....
Oct. 20	....	....	3,091	626	2,186	4,956	3,133	2,766
Nov. 20	....	....	2,832	....	3,154	6,208	155	6,108
Dec. 20	....	....	2,776	....	2,893	5,294	1,250	6,320
Total 1913*	15,885	9,078	24,794	16,725	17,394	21,807	5,280	15,194
Begun work	Mar. 4	May 20	May 3	May 24	May 26	Aug. 14	Aug. 17	Oct. 4 Oct. 4
Work ended	Aug. 17	Aug. 16	Dec. 20	Sept. 27	Dec. 20	Dec. 10	Dec. 20	Dec. 20 Dec. 20

The rotary mixers had an output of	40,157	buckets
The gravity mixers had an output of	86,000	buckets
Total	126,157	buckets

Generally speaking the output of mixers Nos. 4, 5, 9 and 10 was supplied to the guy derricks and that of the others to the traveling derricks. The following is, therefore, approximately true:

Placed by guy derricks	52,050	buckets
Placed by traveling derricks	74,107	buckets

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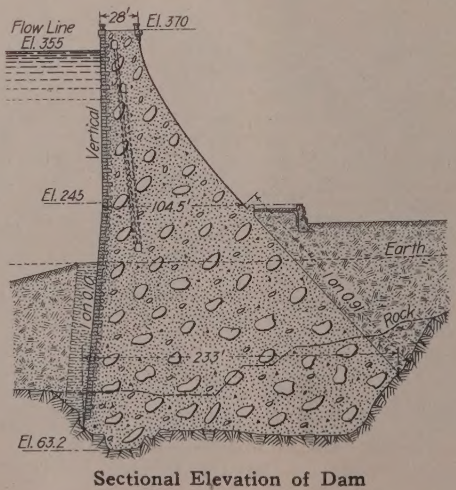
*Correcting for fractions.

TRAVELERS AND SUPPLY TRACKS

Eight travelers, about 40 ft. square and each equipped with two derricks, comprise the standard equipment for this portion of the work. Four travelers face each other across a section between expansion joints. Thus two alternate sections can be built at one time, or as the working areas become smaller or the weather colder, blocks can be laid in one section while concrete is being placed in the other.



Sectional Elevation of Dam

There are two traveler tracks separated by two service tracks for concrete and having on their other sides one track for concrete and one track for cyclopean stone. In the first lift all the tracks were at the same level, but in the second lift only the traveler tracks and the two middle service tracks were at the new level, the outside service tracks being supported on the refill. In the third lift there will be no center service tracks. The size of the piers used precludes the necessity for diagonal bracing, and as the traveler tracks are temporarily removed for 39.5 ft. across the section where work is being done, this provides an unobstructed space. When a section is finished these tracks are replaced and the travelers moved forward to the next section.

LIFTING TRAVELERS TO NEW LEVELS

Changing from one lift to a higher one is exceedingly simple. The traveler track is constructed at the high level, the traveler stripped of its hoists and booms and its four corners made fast to the two cableways and to two of the derricks on the neighboring travelers. Then by concerted action the traveler is lifted, moved over the new tracks and deposited, the actual shift requiring not more than 30 minutes. The hoists and booms are then replaced.

The two overhead cableways perform only this service and the other miscellaneous work that would otherwise require temporary derricks or ginpoles.

The shuttle cars are simply flat cars each equipped with a vertical boiler and a small engine connected with a chain to a sprocket fastened to one of the axles.

MIXING PLANT

For this part of the work the mixing plant consisted during the first lift of three 2-yd. Hains-Weaver gravity mixers. For the second lift the middle gravity mixer was replaced by two 1-yd. Ransome mixers which permitted the shuttle cars to come under them at the higher level. All of these mixers were located in a trestle in which are built the bins and storehouses and on top of which the trains furnishing aggregate come at a gentle grade.

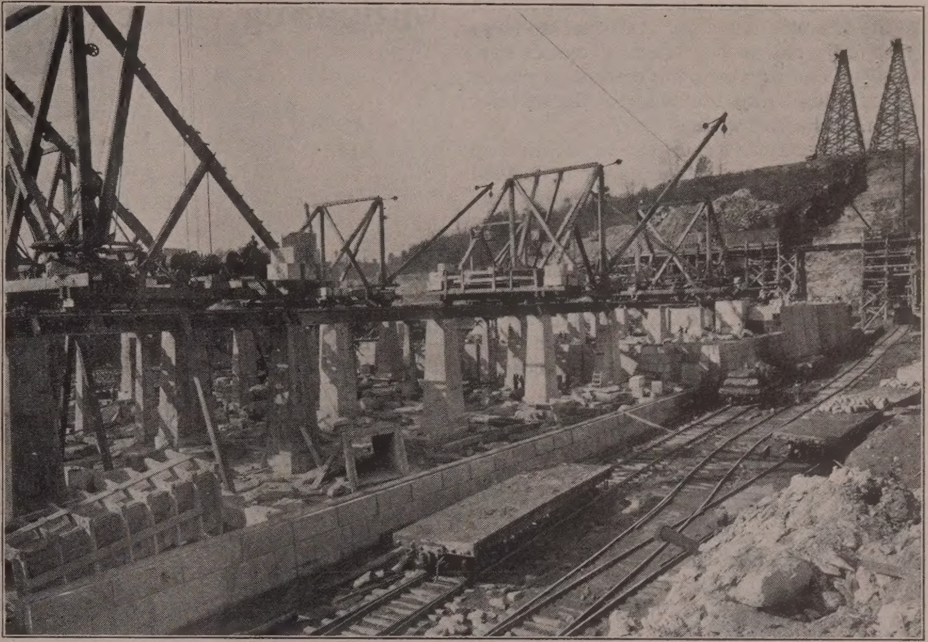
In the accompanying table is shown the output of the various mixers, a division being made between the mixers furnishing concrete to the guy derricks and those supplying the travelers. Quantities are given as the number of buckets mixed per month. The contents of a bucket are about 52 cu. ft. of fluid concrete.

Although the table is arranged so that it is possible to compare not only the different methods of placing concrete, but also the work of the different types of mixers, neither comparison would be fair on account of the long periods covered. There were many things which tended now and then to reduce the rate of one or the other and for which neither the mixers nor the general schemes employed could be held responsible.

MONTHLY TOTALS FOR YEAR 1913 SHOWING CUBIC YARDS OF MASONRY PLACED IN KENSICO DAM

Item	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mass concrete (yds.)	....	540	2,440	1,990	1,920	760	340	1,120	240
Cyclopean concrete	890	8,700	26,850	38,640	44,980	49,850	41,740	44,730	36,970
Concrete blocks placed	....	.....	770	1,670	1,390	2,630	2,850	2,670	1,410
Total in place, month	890	9,240	30,060	42,300	48,290	53,240	44,930	48,520	38,620
Total in place, year	890	10,130	40,190	82,490	130,780	184,020	228,950	277,470	316,090
Concrete blocks cast	1,340	3,380	4,230	4,350	5,500	4,730	3,150	1,500	980
Total cast, year	1,340	4,720	8,950	13,300	18,800	23,530	26,680	28,180	29,160
Total on hand	1,340	4,720	8,180	10,860	14,970	17,070	17,370	16,200	15,770
Grout (yds.)	....	.....	.....	.....	......	10	60	......	......
Cement (bbls.)	2,410	13,250	31,500	39,820	51,215	51,060	39,310	41,010	33,940

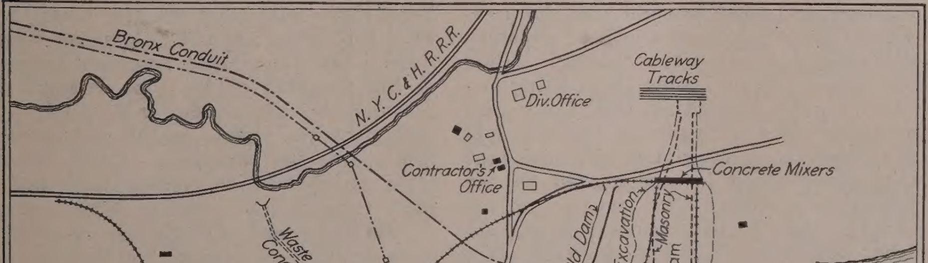
The maximum output of one mixer for any one day of 8 hours was 352½ buckets of 53.5 cu. ft. each, mixed in the gravity type and placed by guy derricks under very favorable circumstances.



Upstream View, Showing Arrangement of Travelers and Piers

As the masonry rises the piers become embedded in it, forming parts of the dam. From time to time new piers are erected and the traveler is elevated.

There will be needed over 60,000 cu. yd. of blocks, and nearly one-half of these have been made this year and placed in the structure or in storage. The block yard, a level area 1100 ft. long and 150 ft. in width, is located on the fill below the dam and was described in The Engineering Record of May 10, 1913, page 528. There are twelve types of blocks for which collapsible steel forms have been provided, and these are placed in three long lines. Each form consists of a face plate placed horizontally, and four side plates, all stiffened with angle irons and assembled with bolts. The upstream face blocks are cast so that the portion to be exposed to the water is on the bottom. The weight of the liquid mass thus serves to assist in securing a surface well flushed with cement and somewhat more dense than can be obtained against one of the sides of the forms.



Plan Showing the Construction Plant and Concrete-Block Yard at Kensico Dam

Throughout the warm weather the side forms were removed within the next day after being cast and on the following day the block was lifted, turned on its side and placed in the storage piles. There were approximately twice as many bottom as side plates, the latter being used with a new bottom while the blocks hardened. Two and one-half days were required for a complete cycle of operations.

Blocks totaling 29,160 cu. yd. had been made previous to Dec. 20, 1913. The maximum output for any one week was 1305 cu. yd. and for the 10 weeks between July 9 and Sept. 17 the total output was 11,750 cu. yd., an average of 196 cu. yd. per week day.

BLOCK YARD MIXING PLANT

The block yard mixing plant differs from the usual equipment in that the mixer itself is brought to the forms on a traveler. This traveler consists of two standard-size railroad flat cars, one on each side of the three rows of forms, supporting three mixers with measuring hoppers, bins and a cement shed, and surmounted by a overhanging beam on which the small supply of aggregate carried is lifted and brought to the bins. It is intended that only sufficient sand and stone shall be carried to provide for the immediate use of the mixers, while a train, always in attendance, goes back and forth to the larger storage bins. These large bins are located near the middle of the yard in a trestle to the top of which trains run directly from the quarry and the sand pit and under which the service trains are run. The sand and stone are carried in buckets which are lifted at the traveler and moved over the bins by a hoist on one of the traveler flat cars. A standard-gage track adjacent to the traveler tracks permits the car in which the cement is placed at the mills being fastened to the traveler and moved along with it.

Three electrically operated 1-yd. Ransome mixers are installed. The power is derived from a main laid throughout the yard parallel to the tracks and connected to the traveler by flexible cables which may be plugged in at intervals. Water is similarly supplied by a flexible hose connected to valves on a main. The traveler is moved by the hoist, around the winch of which is passed a rope connected through blocks to frequent dead-men. The mixers are arranged one directly over each line of forms and are provided with short chutes through which the quantity of concrete desired at the moment is passed directly to the forms underneath. Three forms are thus filled simultaneously and the traveler moved a few feet to the next three forms.

EFFICIENCY OF MIXING PLANTS

The efficiency of mixing and placing plants has taxed the quarry to the utmost. During last winter storage piles of small stone for concrete and large stone for the cyclopean were accumulated only to be long since entirely consumed. New openings were made in the quarry and twelve derricks installed to assist the steam shovel. The quarry work was put on a two-shift basis and yet the output was insufficient.

All tracks are standard gage, thus permitting the original cement cars to come right to the mixers. The power used for the rotary mixers and the hoists is entirely electricity, which is conducted from the Edison plant at Dunwoodie at a potential of 45,000 volts over a steel tower line 12 miles in length. At the power house this is transformed to 2,200 volts, from which the field transformers again step it down to 440, 220 and 110 volts. The various items of plant, in addition to those already mentioned, include sixteen 25 to 40-ton Porter locomotives; sixty flat cars; eighty-two 6 and 8-yd. side dumping cars; twenty 25-yd. gondolas; seventy 2-yd. bottom-dumping Stuebner buckets, three steam shovels, four traveling cranes, forty-one electric hoists and thirty-six transformers.

For operating the drills at the quarry and for other miscellaneous purposes there are three compressors with a combined capacity of 4500 cu. ft. of free air per minute. The quarry is equipped with twenty-one electric pneumatic drills, five well-boring rigs and a large crushing plant with two jaw crushers and a pair of 30 x 60 in. rolls. This plant was fully described in The Engineering Record of Feb. 24, 1912, page 216.

Kensico dam is in the Kensico division of the Board of Water Supply, of which J. Waldo Smith is chief engineer, Frank E. Winsor department engineer and Wilson Fitch Smith division engineer, immediately in charge of the construction. The contractors are H. S. Kerbaugh, Incorporated, of Philadelphia, with Beverly R. Value, chief engineer, and George H. Angell, superintendent.

CEMENT GROUT FILLER is exclusively called for in the new specifications on brick pavements of the New York State highway department, issued Jan. 1. An advisory board had recommended that soft filler only be called for. This matter was commented on in this journal Dec. 20, page 680.

Mitigating Electrolysis from Street-Railway Currents

Discussion of the Most Important Methods That Have Been Proposed and Conclusions Regarding Their Relative Merits

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IN this paper is given a brief discussion of the most important methods of electrolysis mitigation that have been proposed, together with conclusions as to their relative merits.

Painting or otherwise insulating the surface of pipes, as by the use of treated papers and textiles, was early resorted to as a possible means of protecting pipes from electrolysis, and this method is still used in some instances. It is doubtful, however, whether there exists any instance in which it has been definitely proved that insulating paints have effectively protected pipes from electrolysis for any considerable period of time, while there are many instances where they have failed and where their presence has actually done harm.

Practically all paints are classed as insulators, but in practice a given paint may endure for a long period in some places, while in other places in the same city it may deteriorate rapidly and become worthless in a comparatively short time. This is due partly, no doubt, to differences in soil conditions, but the general failure of these paints under conditions where electrolysis was to be expected indicates that the stray currents themselves have much to do with the destruction of the coatings. About forty different kinds of commercial paints have been tested, and of these not a single one has withstood the action of the very moderate test voltage of 4 volts for any considerable length of time, failure of the coating with consequent pitting of the pipe occurring within a few months in all cases.

INFLUENCE OF MOISTURE

The explanation of the failure of the coating lies in the fact that none of the paints tested is absolutely impervious to moisture, and when brought into the presence of water a slight trace of moisture ultimately permeates the coating. When this occurs at any point the coating becomes slightly conducting, and if any electromotive force is applied, a trace of current flows at first, giving rise to slight electrolysis which is accompanied by the formation of more or less gas beneath the coating. As this gas accumulates and expands the coating is finally ruptured, after which the current flow is greatly increased at the point of break-down and rapid electrolysis of the exposed iron follows.

In some cases, if the coating is sufficiently porous to permit the gases to escape, it may remain intact and electrolysis may continue beneath the coating, eating through the metal without any superficial evidence of failure of the paint. This phenomenon is frequently observed in practice. The vital weakness of all the paints thus far tested is due to the fact that they are not entirely non-absorbent. If a paint could be secured which is absolutely impervious to soil moisture and which would remain so for an indefinite period, it would prove an effective preventive of electrolysis, and all efforts to produce such a protective paint should be directed to this one point of making it absolutely and permanently moisture-proof.

TROUBLE FROM PAINTS

The manner in which these paints usually fail under electric stress shows that they may under certain circumstances increase the trouble from electrolysis. Breaking down as they do at isolated points, the discharge of current from the pipes is concentrated at those points and the pitting is likely to be more serious than if the paint were not used at all. In all areas, therefore, where the pipes are strongly positive to the earth these paints are likely to do more harm than good, and it would be better to omit them altogether. But in places where the pipes are practically neutral, or negative to earth, they can do no harm even if they do fail in spots, and in such places they may be of value in reducing current flow in pipes and in preventing soil corrosion.

Coating pipes with treated textiles or tarred paper is open to somewhat the same objections that have been made to the use of insulating paints, the only difference being that the time required for their initial failure is usually greater than in the case of paint. As a means of preventing or even reducing electrolytic damage in positive areas this method of surface insulation does not appear to be practicable at the present time.

INSULATING JOINTS IN PIPES

Another method of reducing current flow in pipes is by insulating or resistance joints. In ordinary wrought-iron or steel mains with screwed or riveted joints the resistance of the joints is usually small in comparison with that of the pipes, and when such pipes are laid in localities where there is an appreciable potential gradient in the direction of the pipe, currents of considerable magnitude will usually be carried by the pipes. In the case of cast-iron mains the resistance of the joint is often as great as, or greater than, that of the section of pipes, and it is not uncommon to find a lead joint having a resistance equal to that of several hundred feet or more of pipe. It is due largely to this high joint resistance and to some extent also to the higher specific resistance of cast iron that cast-iron mains usually carry less current under similar conditions than wrought-iron or steel mains. Experience has shown, however, that the resistance of lead joints is not sufficient to reduce the current to a safe value, and attempts have been made still further to increase the resistance of the pipes by the introduction of specially designed joints of high resistance.

If properly installed, with joints of proper construction and used with sufficient frequency, the insulating joint can be made very effective in minimizing electrolysis troubles. The higher the potential gradients in different parts of the system the more frequently the insulating joints must be used. In most cases it would not be necessary to make every joint insulating, one-third or one-fourth of the joints being usually sufficient even under severe voltage conditions, while in many parts of the system a much smaller percentage would suffice.

With potential gradients reduced to as low a point as practicable under a properly designed negative return, a comparatively small number of insulating joints not exceeding 5 or 10 per cent of the total number would be sufficient to give practically complete protection to the pipes. We wish to emphasize, however, that we regard this method as valuable chiefly as an auxiliary method which may be used in connection with and supplementary to a negative return system of proper design.

PIPE DRAINAGE SYSTEMS

A system of electrolysis mitigation which has received wider application in this country than any other method is that which is best characterized as the "pipe drainage system." This method has taken a variety of forms, among the principal ones being direct taps between pipes and rails. In this form no extensive negative feeder system is used, but at various points throughout the positive areas where the pipes are close to the tracks short heavy cables are connected between the pipes and rails with the view of keeping the pipes at nearly the same potential as the tracks.

It has been objected that the pipe drainage system is not a permanent system, requiring constant watching and changing when the distribution of the street railway load or of the pipe systems undergoes any marked change. This objection is no doubt an important one where the uninsulated system of pipe feeders is used, but it would not be of serious moment in the case of the insulated feeders with resistance taps, since by the insertion of proper resistances in the various feeders they could be adapted to widely varying conditions as regards load distribution.

A second objection is the fact that any form of pipe drainage will necessarily increase to a greater or less degree the amount of current carried by the pipes, which is accompanied by the ever-present danger of trouble developing in the vicinity of high-resistance joints at obscure and unlooked-for places.

A third objection is that the connection of the pipe system to the busbars or rails lowers the potential of the pipes and tends to make them negative to other pipe and lead cable systems, thereby endangering the latter. The advocates of this system attempt to avoid this objection by recommending that all pipe and cable systems be included in the installation. In any case it would greatly extend the area in which acute troubles might be expected and the expense of watching and guarding against trouble would be largely increased.

A fourth objection, resulting from the great tendency of this system to increase the current flow in the pipes, is the increased life and fire hazard which it introduces, particularly in connection with gas systems.

A fifth objection, and an important one, is that the application of this system requires that all pipe systems to which it is applied shall be electrically continuous throughout. If the drainage plan were applied to a pipe system containing any considerable number of these insulating joints it would result in the certain destruction of the pipes.

A sixth objection to the general application of the pipe drainage system as a means of electrolysis mitigation arises from the tendency toward the production of an excessive amount of alkali at the surface of a negative electrode embedded in earth. The concentration of alkali at the negative terminal will have no detrimental effect in the case of iron pipe but may tend considerably to increase the self-corrosion in the case of lead service pipe.

PIPE DRAINAGE ONLY A PALLIATIVE, NOT A REMEDY

What appears to us, however, as being the greatest objection to the pipe drainage system, and this applies also to all the other methods applied directly to the pipes, is the fact that they are designed to relieve the symptoms rather than to remove the cause of the trouble. They are, therefore, fundamentally in the nature of a palliative, rather than a remedy. In general, our study of the pipe-drainage method has convinced us that while it may under certain conditions be useful as a secondary means of lessening trouble, its installation as the principal means of electrolysis mitigation is an unwise procedure, not so much because the immediate consequences are bad, since the contrary is quite the rule, but because of the ultimate consequences to which this method, when once resorted to, must inevitably lead.

In its practical working out it exhibits two opposing tendencies, namely, (1) the reduction of the difference of potential between pipes and rails in the positive areas, with consequent reduction of damage at those points, and (2) an increase of the danger to the pipes throughout the entire system, as indicated above. We confidently believe that a system worked out on these lines will ultimately lead to much greater expense and less satisfactory protection than will result from other installations designed along the lines outlined in a later section of this report.

CHEMICAL PROTECTION

Chemical protection contemplates surrounding pipes with certain chemicals, such as lime, etc., which are known to have a tendency to inhibit corrosion under certain circumstances; the use of cement coatings on the pipes; cathodic protection, or protection of pipes by maintaining them negative to certain structures by means of battery, motor generator, etc.; favorable location of pipes with respect to rails; the use of non-corrodable conducting coatings, and what may be termed electric screens, which are sheets of metal placed near to or surrounding a portion of the pipe and electrically connected thereto. While certain of these may have a temporary value for reducing electrolysis troubles under very special conditions, our investigations have convinced us that none of these methods can be seriously considered in connection with the permanent mitigation of electrolysis under average conditions of practice.

RAILWAY RETURN SYSTEM

None of the systems of electrolysis protection mentioned has to do with the nature or condition of the street railway return system, and in the practical working out of such methods the railway return system is usually ignored. It would appear more logical to attack the problem by beginning at the source of the evil and to prevent, to a large extent at least, the leakage of the currents from the railway return conductors into the earth.

Of the various methods that have been proposed for application to the negative return of the railway system, the majority are either inadequate or impracticable under ordinary conditions when considered solely as means for reducing electrolysis troubles. Among these may be mentioned alternating-current traction, grounding of tracks and busbars, periodic reversal of trolley polarity and the use of the double-trolley system. There is no question, of course, that the double-trolley system, if properly installed, would entirely eliminate electrolysis from railway currents. This system as at present used in Cincinnati, Ohio, and Havana, Cuba, and the corresponding underground conduit system as used in Washington and in New York City eliminate almost completely the danger of electrolysis, the small leakage which does occur being of no practical consequence. The chief objections to their use are the cost of installation and the increased operating difficulties which are involved. The cost of installation in fact does not appear to be justified merely as a means of electrolysis protection, inasmuch as a very satisfactory degree of protection can be obtained by other and much more economical means.

PROPER MAINTENANCE OF TRACK

Proper maintenance of the track in order to secure high conductance is everywhere recognized as a necessary condition in electric railway operation, but it does not always receive the attention that its importance justifies. Experience to date indicates that welded or other types of electrically continuous joints are very satisfactory in all cases where the tracks are laid in paved streets or otherwise suitably reinforced. As a precautionary measure, however, some engineers prefer to bond also over all joints. Cross bonding between the rails is also much resorted to as a precaution against the troubles arising from bad joints. These cross bonds are usually placed at intervals of from 200 ft. to 500 ft. and those distances are sufficient if the cross bonds and rail joints are fairly well maintained. All special work should be shunted by copper cables capable of carrying all of the current passing over the tracks at that point.

A properly drained roadbed is also a very effective aid in reducing the leakage of stray currents from the rails, since the conductance of the leakage path is mainly dependent on the amount of moisture which is contained in the material forming the roadbed and the earth beneath. Indeed, we have made tests on long lines of track without intersections to cause complications, in which it was found that leakage from the rails to earth was almost entirely eliminated because of the high resistance of the leakage path.

UNINSULATED NEGATIVE FEEDER SYSTEM

The uninsulated negative feeder system has been much used in this country as a means of increasing the conductance of the track, especially in the regions near the power houses, where, as a rule, the current densities become high. The benefits that accrue from its use are threefold: (1) The reduction in potential drop in the rails, thereby lessening damage due to electrolysis; (2) the saving in power; (3) the maintenance of a more uniform voltage on the cars, especially at times of peak load, thus giving rise to improved car service and better car lighting and reducing the maximum demand. When these benefits are carefully considered it seems somewhat surprising that the use of negative feeders is not more common. While we do not regard this as being in general an economical system, it possesses merits as compared with systems in which no feeders are used.

INSULATED NEGATIVE FEEDER SYSTEM

In the insulated negative feeder system, instead of tying the track rails directly to the negative bus and depending on the rails and such copper as may be in parallel therewith to return the current to the power house, the connection at the power house is either removed or given a suitable resistance, and insulated feeders are run from the negative bus to various points of the track. By this means two important results may be achieved. In the first place, the current being drawn from the rails at numerous points, high-current densities, and consequently high-potential gradients in the rail, are avoided. In the second place, it is possible, by so designing the system that the drop of potential on all of the feeders is the same, so to subdivide the current flow in the tracks that the direction of the flow will be frequently reversed, thus preventing the accumulation of large potential differences between points on the tracks some distance apart. It will be evident that in this case the actual drop of potential on the different feeders is of secondary importance so long as it is practically the same in all, in so far as the potential difference in the track is concerned. We can thus impose any desired potential restrictions on the track and still be free to design the feeders to give maximum economy, something we cannot do when the feeders are connected in parallel with the tracks, as is most commonly the case in practice.

BOOSTERS IN SEPARATE FEEDERS

A method which has found considerable application in Europe but is comparatively little used in this country is that of carrying insulated negative feeders to various points on the track and inserting a booster in each feeder. The two advantages of this method are that a great economy of copper in the negative feeders can be obtained as compared with uninsulated negative feeders and, by varying the voltage of the individual boosters, almost any desired potential condition can be obtained in the track network. To offset these advantages we have the large first cost of the boosters and an increased depreciation and operation cost. In a large district as many as a dozen or more negative feeders may be required, and the use of a booster with each of these would obviously introduce considerable complication in the operation of the station. While this system is capable of giving very satisfactory results, so far as potential conditions in the tracks are concerned, we do not believe that the expense and complication of it are justified.

If insulated negative feeders are used without boosters, the layout of the negative feeder system will be very similar to that in the case of the booster system described, the chief difference being in the elimination of the boosters. The potential drop necessary to force the required current through the negative feeders without the use of additional copper is obtained by removing the direct tie between negative bus and rails at the power house and substituting in its place a properly designed resistance tap.

The simplicity of this system as compared with the negative booster system is obvious. In fact, the chief objections that have been urged against the negative booster system are overcome, namely, the cost of booster equipment, together with elaborate switchboard apparatus for controlling it, the space occupied by the boosters, which is out of all proportion to their kilowatt capacity because of the large number of small machines required, and, finally, the time and expense involved in caring for these machines. In the matter of power loss there will in most cases be an advantage in favor of the plain insulated feeder system. In either case the loss in the cables would be approximately the same, since all but the very short cables would be designed for maximum economy.

Against these decided advantages of the resistance tap method over the booster method may be set the possible objection that the former is less flexible than the latter and cannot be made to respond as readily to meet the exigency of shifting loads. This objection is apparent rather than real, since the really important consideration is to take care of average normal conditions, and this the system will do automatically if properly designed. Abnormal conditions, such as blockades or other temporary bunching of the load in one locality, are usually of so short duration that such disturbances in the rail gradients as would result therefrom would have no appreciable influence on the electrolysis problem. This method is a thoroughly practical one, and if properly installed can be made to reduce potential gradients in the rails to any desired degree, and under many circumstances it is the most economical effective means that can be installed for reducing electrolysis.

CONCLUSIONS

The insulated feeder system is available for general application, is comparatively cheap to install and introduces but slight complication into the operation of the system. It is possible by the proper application of this method to reduce the potential gradients in the earth to almost any desired degree at a comparatively small cost, and it can consequently be made very effective in relieving electrolysis troubles. In special cases, however, it may sometimes be better, where conditions are favorable, to combine one of these methods with either the insertion of a moderate number of insulating joints in pipes or with the use of a very limited amount of pipe drainage, the insulated feeder system being applied to reduce potential gradients throughout the system to a very low value and one or the other of the previously mentioned auxiliary systems used practically to eliminate any residual electrolysis that might still remain.

Insulated feeder systems of the general type described have in recent years been advocated by a number of engineers in this country, but their application has been limited to a few instances, and for the most part to rather special conditions, and for this reason no adequate experimental data as to their actual performance under practical conditions of service have been published. The writers have recently had opportunity to carry out somewhat complete investigations on feeder systems of this character, and the results of these investigations will be published in the near future. To those desiring to study in greater detail the principles so briefly referred to in the foregoing paper we refer to the following technological papers issued by the Bureau of Standards, which can be secured at any time upon request: "Methods of Preventing Electrolysis from Street Railway Currents," "Special Studies in Electrolysis Mitigation," and "Electrolysis from Street Railway Currents and Its Prevention."

Eradicating Moss and Willows from Irrigating Ditches

DISKING canals while the water is running is reported in the "Reclamation Record" by Mr. J. G. Camp, manager of the Klamath project, as a successful means of eliminating growths of moss in the Bear River and Cache Valley projects in California. Practical eradication was accomplished in three years by Mr. Whelan, the manager. An ordinary disk harrow is stripped of seat and double trees. The tongue is cut to 4 ft. in length. To this are hitched two ropes, one leading to a team on each bank. By adjusting the length of these ropes the harrow can be run on either slope or on the bottom. Mr. Whelan claims that this digs up the roots, and they float down with the moss and are removed. He says that his canals were very foul. The first year he had to go over them three times, the second year twice, and now he needs to clean them only once. Very little moss is left, and he thinks this method will work very satisfactorily anywhere. It is cheaper than mowing the moss, it does not interrupt the flow of the water, and it helps to puddle leaky portions of the canals. Mr. Camp believes some kind of a cross-beam with a wheel on each bank could be arranged and the disk harrow hitched to that.

Mr. Whelan also claims to have conquered the willows that grow on ditch banks. He cuts them at the beginning of the dark of the moon in July. At first thought this seems a part of the old fallacy of planting in the different phases of the moon, but he explains that decay takes place in the roots much quicker in the dark than the light, hence the dark nights help. July is hot and the willows are less vigorous then.

CEMENT IS HANDLED IN BULK for the construction of the new plant of the Baldwin Locomotive Works at East Chicago, Ind. The foundations involved more than 10,000 cu. yd. of concrete, and Universal cement in bulk was brought to the contractor's attention as a means of making a considerable saving. Cars are spotted alongside the mixer bins and both sand and gravel are delivered directly to the bins by a clamshell bucket. Bulk cement, however, required a system of elevator buckets on an endless chain and a modified grain shovel. For dragging cement to the car door a dragging shovel, operated by power and guided by a laborer, is placed in the car and manipulated in a manner similar to that of a grain-handling shovel or a scraper.

Automobiles for Transferring Railway Passengers Around Burning Tunnel

Fighting a Stubborn Tunnel Fire

Portals of Southern Pacific Bore Were Sealed and Steam and Carbon Dioxide Forced In to Stifle Flames—Intense Heat Caused Slides and Caves

A DISASTROUS tunnel fire paralyzed traffic on the Coast Division of the Southern Pacific Railroad from Sept. 17 to Nov. 15, 1913. A camp fire started by tramps on the right-of-way kindled the brush near by, spread to the east portal, constructed of timber, and before it was discovered had been drawn by the draft well into the interior of tunnel 7, which pierces a spur of the Santa Marguerita Range just north of San Luis Obispo, Cal.

STEAM TURNED INTO SEALED TUNNEL

The bore is 1371 ft. in length, with a 580-ft. tangent in the center and 10-deg. curves on either end. The grade is 2.2 per cent, compensated, descending toward San Luis Obispo. Water trains were sent from that town immediately after the fire was reported, but by the time they arrived at the scene the blaze had gained such headway that it was impossible to carry hose lines far past the portals to direct streams against the flames. It was at once decided to seal both ends of the tunnel, leaving a small aperture through which steam could be forced into the interior. Three carpenter crews were rushed to the work by special trains and proceeded to erect airtight barricades across the openings. At the west portal two 10 x 14-in. posts were set almost vertically and a tier of 10 x 14-in. timbers was then laid horizontally against them. All small apertures in the barricades were calked with burlap and mud, sacks of earth being used to fill the larger ones. At the east end 3 x 12-in. redwood planks were placed vertically across the entire opening, heavy canvas was stretched over the redwood surface and a tier of 10 x 14-in. timbers piled against this. These seals were completed early on the morning of Sept. 18, and steam supplied by locomotives was forced into the tunnel continuously for seventy-two hours. To prevent any escape of steam a small force of men was kept continuously calking the barricades.

During these operations passengers of Coast Line trains were transferred around the tunnel by automobiles supplied by the Southern Pacific Company.

PORTALS CAVE IN

Soft serpentine with some shale is the formation through which the tunnel passes. At the end of seventy-two hours the disintegrating action of the steam on the serpentine caused several caves near the portals and opened long cracks above and back of the seals. It was therefore deemed advisable to substitute for steam carbon dioxide. Of this gas two hundred tanks arrived on Sept. 20. Each container was under a pressure of 1000 lb. per square inch. When released the gas expanded to seventy times its volume under compression.

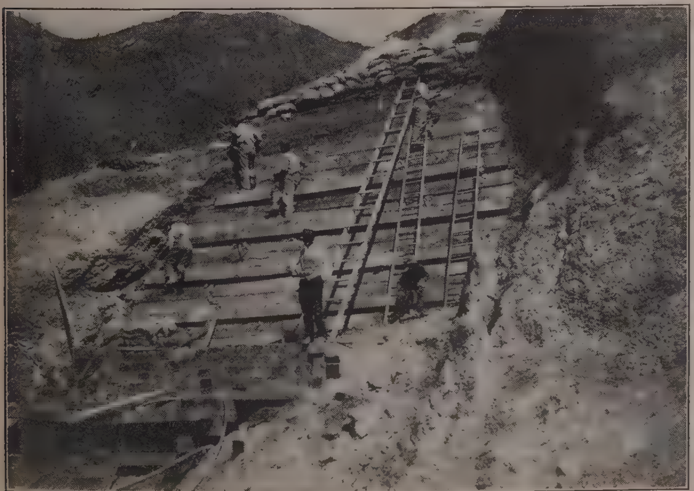
Carbon dioxide was injected through a small opening in the barricade for eleven hours. After waiting an additional twenty-four hours the seals were removed. As soon as this had been done a large cave occurred at the west portal. The heat was intense, registering 302 and 190 deg. Fahr. at the east and west ends respectively. It was generally conceded that the fire still burned in the interior. Later a hasty, perilous inspection showed that about 500 ft. of the tunnel lining near the west portal were unburned but that the flames still smoldered within.

STIFLE FLAMES WITH CO_2 GAS

It was then decided to reseal the tunnel and again inject carbon-dioxide gas. Accordingly, the barricades were rebuilt on Sept. 23 and 13,032 lb. of carbon dioxide forced into the tunnel through the east barricade. By Sept. 25 the temperature at the east portal had dropped to 176 deg. and at the west portal to 118 deg. Fahr. The chemist in charge of the gas-extinguishing process was of the opinion that the fire could not possibly be still alive, so the seals were removed. The temperature immediately rose, so an attempt was made to erect a barricade and airtight seal within the tunnel, 216 ft. from the west portal. The object was to save as much of the timbering intact as possible. The intense heat forced the workers to abandon their labor on this shield before it was completed. Attempts to seal the tunnel at 200 ft. and 60 ft. in from the portal likewise proved futile.

FORCED DRAFT RESORTED TO

All of the timber lining still intact was near the west portal. It was thought that if a plan could be devised whereby the draft in the tunnel could be forced from the west portal toward the east the unburned section could be saved. For this purpose, after the east portal had again been sealed, a chimney 3 x 4 ft. in section and 24 ft. long was inserted near the seal. This flue was open top and bottom, with an aperture in one side. By utilizing the principle of the Sprengle air pump and forcing steam through from the bottom to the top gases were drawn from the tunnel through the aperture in the side of the flue. After maintaining this forced draft for three-quarters of an hour it was discovered that a partial vacuum existed at the east end of the tunnel, while a dense cloud of smoke and gas continued to issue from the west end. This proved that a large slide must have completely closed the tunnel. On removing the seal from the



Calking Apertures in Tunnel Seal, East End

Removing Debris from Earth Slide at Tunnel Portal east end it was found that piles of embers still smoldered along the track within.

OXYGEN HELMETS AND 5-MINUTE SHIFTS

Two members of the San Francisco fire department arrived at the scene on Sept. 27, and by using oxygen helmets were able to inspect the tunnel for some distance in. Their plan, which was adopted, was to erect on a push car a bulkhead that could be advanced along the track and used as a shield against the heat while they fought the fire with hose streams and chemical extinguishers. To afford further protection to the firemen, an air line with breathing nozzles attached was advanced with the water hose. By this plan crews that worked for five-minute shifts fought their way in for 350 ft., extinguishing the blazing lining as they went. When they reached that point fire burst out between them and the portal, rendering a hazardous flight through the flames necessary. During their retreat many were overcome and fell unconscious among the embers. These were rescued by their heroic comrades, who returned into the flames and carried them out to safety. Seventeen were thus rescued, of whom eleven had been overcome by smoke and heat and six injured by falling rocks and timbers.

All hope of checking the fire was soon abandoned. When the west portal had been partially consumed, slides occurred from three sides, practically closing that end of the tunnel.

RECONSTRUCTION

On the morning of Sept. 28 a steam shovel at the east end began to remove the débris. Temporary portal timbers were erected and a crew put to work laying track. This was both difficult and dangerous, as the temperature within was over 160 deg. Fahr. for several days thereafter. Not until an air blower was installed did the heat diminish. Water was used to cool the floor and track, but the rapid cooling increased the danger of caves and falling rock. An average depth of 3 ft. of spawls and débris covered the track, which was so badly distorted that entire renewal was necessary. Even the ties had been almost entirely consumed.

Carbide lights were used at first, but these increased the temperature, and due to lack of oxygen in the tunnel the danger of their exploding was ever imminent. An electric-lighting system was therefore installed, current being supplied by Pyle generators.

As soon as the temperature would permit a steam shovel removed the cave at the west end. Temporary timber portals were erected while the surrounding rock was still at a temperature of 274 deg. Fahr. Work progressed favorably for a distance of 800 ft., where a slide 110 ft. in length extending up into the mountain an indeterminate distance had entirely blocked the bore. A similar slide, 24 ft. in length, occurred just ahead of the shovel that was working in from the east end and knocked out one set of the newly erected timbers. A 6 x 6-ft. drift was driven through the top of this slide under the most trying conditions, the object being to support the treacherous ground above before removing the caved material. The temperature was over 140 deg. Fahr. Fumes constantly overcame the miners, and the ground worked badly. The task was accomplished in three days and breast boards were then driven and timber sets erected. The ground above continued to fail, however, and as timbers in the drift showed signs of failure additional longitudinal timbers 12 x 14 in. in section and 32 ft. in length were inserted and braced. Excavation was then begun beneath, posts being placed to support the drift timbering as rapidly as material was excavated.

During the course of reconstruction a total of 11,780 cu. yd. of rock and earth was removed. Of this quantity 2890 cu. yd. were from the largest slide. In all, 206 sets of timber, generally at 8-ft. centers, were erected and the roof logged and packed. An average force of 250 men was employed. The tunnel was opened and traffic resumed on Nov. 5. Intermediate sets of timbers at 4-ft. centers were then erected and work was begun on new concrete portals and concrete lining where the largest slide took place, about 900 ft. from the east end. It is planned to line 100 ft. with concrete at the west end, 50 ft. at the east end and 100 ft. at the slide.

Temporary Portal Reconstruction

The work was under the direction of Mr. J. M. Davis, general superintendent of the Southern Pacific Company; Mr. R. M. Drake, district engineer; Mr. T. Ahern, division superintendent, and Mr. E. C. Morrison, division engineer.

Economy of Motor Trucks

Records of Large Users, Showing Comparative Costs of Deliveries by Horse-Drawn and Motor Vehicles

RECOGNIZING the utterly disproportionate cost of short-haul transportation over streets and roads as compared with long-distance service by rail or water, and believing that the increasing cost of horses and their keep will offset the advantages of better roads and preclude the possibility of economy with horse-drawn vehicles, the Automobile Chamber of Commerce, through Mr. H. W. Perry, secretary of its commercial vehicle committee, has assembled figures on the delivery costs of large users of wagons and motor trucks. The accompanying table gives the business of the user, the number and kind of motor vehicles in use, and the costs in various units, compared wherever possible with costs for horse-drawn wagons. The records are based mostly on service of from six months to a year, although in one case they extend over seven years. The operating companies were located in New York, Chicago, St. Paul, Memphis and numerous other cities.

POSSIBLE SAVING

The figures indicate an average cost of hauling by motor of 11¼ cents per ton-mile, as compared with 17¾ cents by horse. This represents a saving of 36 per cent. The costs of delivery of packages of merchandise from the stores are respectively 8 and 15 cents for motor and horse, showing a saving of nearly 50 per cent for the former. The head of a Chicago cartage company has prepared figures to show in concrete form the saving possible in that city. He states that more than 250,000 tons of freight are hauled daily through the streets of Chicago, and that this represents an annual business of $60,000,000, or $25 for each inhabitant. In the city there are 50,000 horse-drawn wagons and 4000 motor trucks and wagons. He thinks the 50,000 could be replaced by 20,000 motor vehicles, and that the direct saving would be from $20,000,000 to $30,000,000 per year, or $12 for each inhabitant.

COST OF HAULAGE AND DELIVERY BY MOTOR AND HORSE-DRAWN WAGONS

Business	Number of vehicles	Kind	Dollars per day		Cents per Mile	Cents per ton mile		Cents per package	
			Motor	Horse	Motor	Motor	Horse	Motor	Horse
Department store	24	......	....	....	11.68	....	....	3.67	....
Clothing	1	Gas	7.25	....	....	....	....	10.33	....
Department store	1	Electric	....	....	....	....	....	5.6	....
Contracting	2	Gas	....	....	25.3	9.85	16.07	....	....
Department store	52	......	9.77	....	....	....	....	....	....
Omnibuses	2500	Gas	13.22	....	12.84	....	....	*2.13	....
Department store	14	Electric	....	....	10.8	....	....	....	....
Department store	18	Electric	....	....	7.52	....	....	....	....
Department store	1	Gas	....	....	9.48	....	....	....	....
Department store	1	Gas	....	....	23.12	....	....	....	....
Department store	1	Gas	....	....	24.51	....	....	....	....
Department store	3	Gas	....	....	....	....	....	3.0	6.0
Cut stone	2	Gas	14.29	....	....	15.3	....	....	....
Express	5	Gas	12.00	....	....	6.0	10.0	....	....
Meats	1	Gas	7.17	13.26	....	....	....	....	....
Groceries	6	Gas	....	....	....	....	....	2.5	4.5
Pork packing	1	Gas	8.32	13.27	....	....	....	....	....
Contracting	6	Gas	17.20	....	37.6	....	....	....	....
Produce	3	Gas	11.95	16.80	....	....	....	....	....
Department store	6	Gas	16.20	33.00	....	....	....	8.0	11.0
Coal	17	Gas	9.40	....	27.5	11.3	....	....	....
Brewery	1	Gas	....	....	....	....	....	8.5	20.0
Oil	1	Gas	....	....	....	32.6	....	....	....
Oil	1	Gas	....	....	....	7.62	....	....	....
Oil	1	Gas	....	....	....	7.94	....	....	....
Furniture	10	......	....	....	....	....	....	24.33	35.0
Bulky goods	10	......	....	....	....	....	....	10.5	14.75
Meats	2	Gas	4.19	7.42	....	....	....	....	....
Wagon works	1	Gas	....	....	....	14.9	27.7	....	....
Meats	29	Electric	....	....	....	7.89	17.28	....	....
Meats	..	Gas	....	....	....	8.04	....	....	....
Laundry	5	Gas	....	....	11.0	....	....	2.66	....
Hauling coal	..	Electric	12.00	....	41.6	8.3	....	....	....
Coal	3	Electric	10.34	....	....	7.5	....	....	....
Coal	..	Electric	12.64	....	....	13.3	....	....	....
Coal	..	Electric	....	....	....	6.7	....	....	....
Average			11.06	16.75	20.24	11.23	17.76	7.90	15.04

*Cost per passenger.

Reinforced-Concrete Standpipe with Sliding Base

Cylindrical Wall of Structure 100 Feet High and 40 Feet in Diameter at Fulton, N. Y., Is Disconnected at Bottom and Sealed by Special Joint

By WILLIAM MUESER
M. Am. Soc. C. E., New York City

A REINFORCED-CONCRETE standpipe of 40-ft. inside diameter and 100 ft. in height from bottom to overflow has recently been completed at Fulton, N. Y. It is of a new type which the writer has advocated for some time and breaks with the old practice of firmly connecting the circular wall with the bottom. The cylindrical wall is not only disconnected from the bottom by a distinct joint, but by the use of anti-friction materials in the construction of the joint the expansion and contraction of the circular wall under changing water pressures is facilitated, and an elastic asphaltic seal which adjusts itself to these changes waterproofs the wall against the bottom.

SHEAR CRACKS

The old method of increasing the thickness of the wall at the bottom and providing shear bars connecting these two elements has not proved successful in preventing horizontal cracks in the concrete tank and consequent leakage. Such shear cracks as have usually appeared in concrete tanks near the base have frequently been credited to imperfect workmanship or the impossibility to properly connect old and new concrete. The writer has long since been convinced that the fault has been with the old method of design. In fact, there seems to be no good reason why the bottom, which has to take care of the vertical pressure, and the wall, which is provided to confine the water, taking care of the horizontal pressures, should be artificially and carefully connected, thereby creating at the juncture a condition causing unnecessary secondary stresses in the wall and bottom due to the elastic deformation of materials under stress, which must be provided for in the design.

The standpipe at Fulton is of the Mueser type and consists of two main elements—the bottom, which is independent and subject only to vertical pressures and is therefore simple, safe and economical and easily designed; and the circular wall set loosely on the bottom so that the shearing stresses in the wall are reduced to the minimum and the usual shear cracks eliminated.

At the joint the concrete base is troweled to a smooth finish, then plastered with a 1/8-in. coating of graphite paste and covered by a 20 gage copper sheet on which the wall rests. Possible leakage through the joint is prevented by a trapezoidal asphalt wedge on the inside of the wall, 8 in. high, as indicated on the drawing. It is evident that with sufficient flexibility of mastic this joint will always be tight—in fact, the higher the water pressure, the tighter the joint. Should the asphalt seal be of bad quality or in time become brittle, it would be an easy matter to scrape the V-gutter and fill it with live material. One of the illustrations shows the finished base, to which the graphite paste and copper sheeting are being applied.

REINFORCEMENT

The wall is 18 in. thick throughout to facilitate the formwork, as the designers intended that the entire wall should be built monolithic with sliding forms if possible. It is reinforced by rings of Diamond reinforcing bars, 1½ and 1¼ in. in diameter, spaced from 3¼ to 9 in. on centers, the rings being in two vertical planes to facilitate erection and distribution of the steel in the wall. Z-shaped struts each made of two 3 x 3 x ¼-in. angles and spaced equally on a 41½-ft. diameter circle—in the center of the wall—serve to support the reinforcement, which is held in place by ¼-in. round clips. Joints in the reinforcement are made by overlapping and splicing with two ¾-in. round clamps. Such joints are staggered at least 10 ft. for two consecutive rings and the overlap is 51 in. for 1½-in. bars and 39 in. for 1¼ in. Three bars are used per ring.

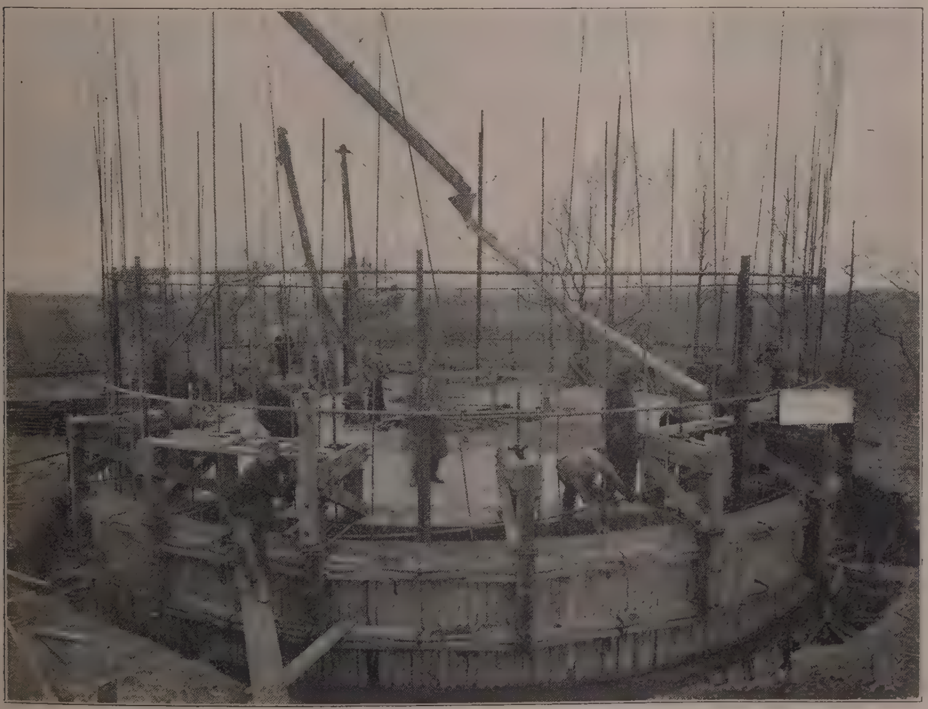
In addition to the supporting struts there are seventy ¾-in. bars, seven between each pair of struts, equally spaced to form the vertical reinforcement, but forty of these bars reach only to a height of 30 ft. Six overflows, 18 in. wide, are placed in the wall 100 ft. above the bottom of the standpipe.

At the top the tank is surmounted by a reinforced-concrete dome with a 10-ft. 9-in. rise, topped with a lantern. The total height of structure from lowest to highest point is 117 ft. 1 in. Access to the interior is gained by a steel ladder going up on the outside of the tank, bent around its coping and descending downward on the inside through a manhole in the roof. This ladder is supported on the top of the wall, but bolts screwed into bronze sockets embedded in the concrete serve as spacers.

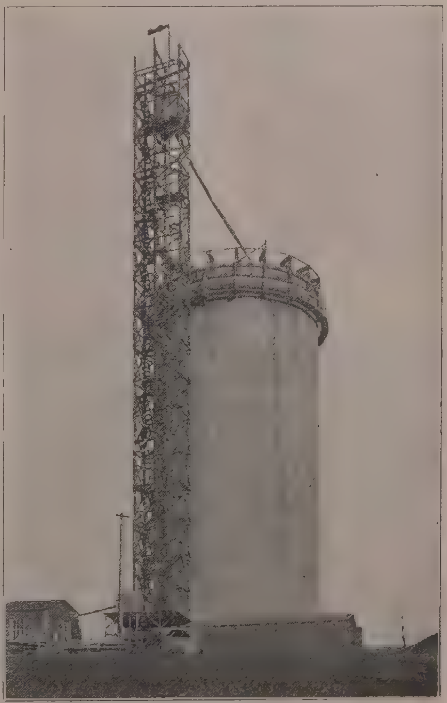
CONSTRUCTION

Under the standpipe the foundation consisted of gravel with very fine sand in alternating, inclined and not uniform layers, requiring a redesigning and strengthening of the original foundation plan. After the excavation had been completed according to the changed design, the reinforcing bars were placed and the concrete deposited. No forms were used except a rim forming the slope of the groove for the asphalt. This form was made of two horizontal boards, spaced 8 in. and provided with a facing of plaster of paris. The 1:2:4 concrete was deposited continuously and the foundation slushed with grout before commencing concreting. A wearing surface 1 in. thick, composed of 1 part cement and 1½ parts of crushed granite, was built on top of the foundation and troweled to a smooth finish.

After four days, when the foundation



Connecting and Jacking Up Forms with Threaded Spindles and Capstan Nuts



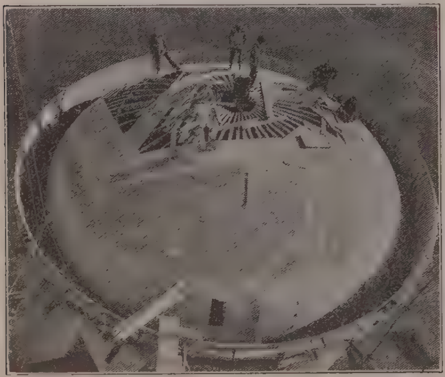
Standpipe and Concrete Tower

Slip Joint with Paste and Copper Sheet

appeared to be sufficiently hardened, the graphite paste was applied ⅛ in. thick, smoothed and pressed hard onto the concrete. The paste was made of graphite and mineral oil. Upon this anti-friction paste was then laid a ring of 20-gage copper sheet, approximately 1/32 in. thick and 26 in. wide.

USE OF SLIDING FORMS FOR MONOLITHIC CONSTRUCTION

Continuous concreting was used in the walls so as to get a monolithic structure without horizontal seams, the work being done in three shifts. Erection of steel rings and concreting proceeded simultaneously day and night. To permit continuous progress without any delays for erection of forms the forms were built 5 ft. 4 in. and outside and inside parts were rigidly connected overhead by twenty frames spaced equally. The inner forms were connected with and supported the working platform, which, therefore, was moved up simultaneously with the forms. A jacking arrangement, consisting chiefly of a movable screw and a stationary nut, was provided at each of the twenty frames or cross connections. This screw has a 3½-ft. extension inserted in a gas pipe and supported at its top on a washer. This feature, patented by Mr. A. D. Whipple, of Milwaukee, worked very successfully. When the form had been moved up far enough to necessitate a longer pipe, the screw was turned up and a new 3-ft. section of gas pipe was inserted. Above the nut on the screw a capstan nut was arranged, supported by a steel plate, which was turned a quarter turn by using a short bar, thereby lifting the form at that point about ⅛ in. One man going around and turning each of the capstans a quarter or half a turn kept the forms in a steady motion upward.



Form Work of Dome Nearly Completed

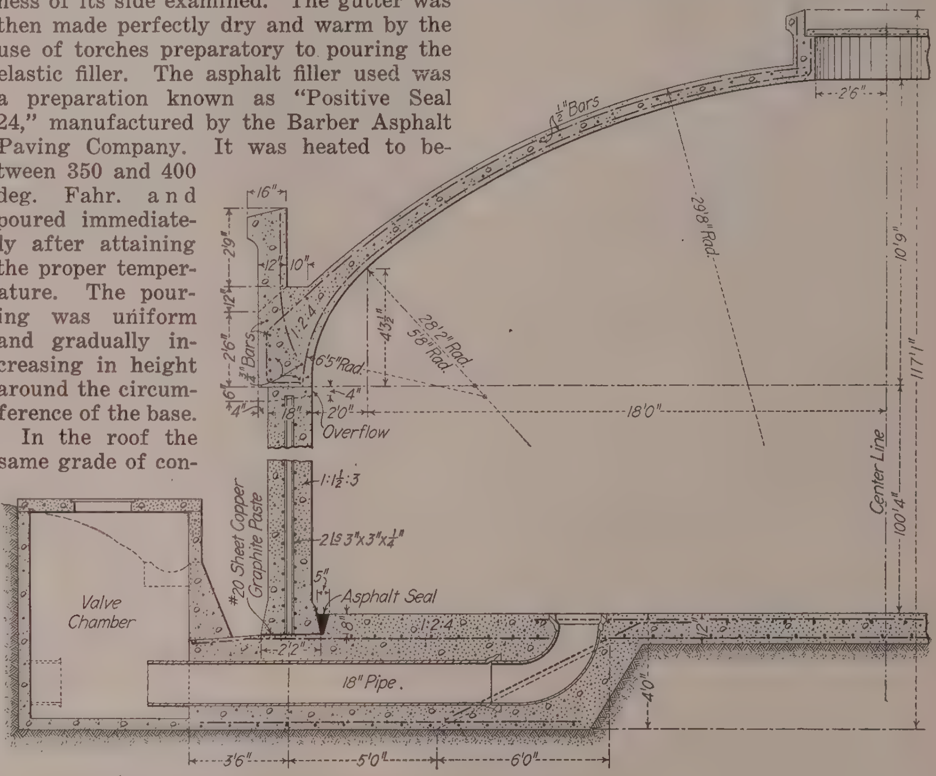
Every six hours the alignment of the standpipe was checked up on four plumb bobs on the outside of the standpipe. From the time of starting concreting of the wall to the finish of it 20 days and 5 hours elapsed, which is believed to be a record.

No waterproofing compound was used in the concrete, but every effort was made to produce maximum density for the mixture. As the form progressed the outer surface of the wall was rubbed with carborundum bricks and water. A second and final rubdown was given the wall after completion, starting from the top down.

ELASTIC FILLER TO SEAL BASE

When the wall was completed the groove on the inside of the wall between it and the foundation was cleaned and the dryness of its side examined. The gutter was then made perfectly dry and warm by the use of torches preparatory to pouring the elastic filler. The asphalt filler used was a preparation known as "Positive Seal 24," manufactured by the Barber Asphalt Paving Company. It was heated to between 350 and 400 deg. Fahr. and poured immediately after attaining the proper temperature. The pouring was uniform and gradually increasing in height around the circumference of the base.

In the roof the same grade of concrete was used as for the foundation, a 1:2:4 mixture. One of the photographs shows the formwork nearly completed. The depositing of the concrete was continuous and the outer forms were removed as soon as possible and the surface rubbed smooth with carborundum stones. A cast-iron manhole with cover was placed where the ladder enters the tank.



Details of Design for Standpipe with Disconnected Base and Flexible Seal

An 18-in. cast-iron plate furnishes the connection between the standpipe and the water supply system. Around the bottom of the tank is a gutter to collect possible leakage. This gutter is provided with a drain so that no water can collect.

This standpipe replaces an old steel standpipe of about one-fifth its capacity, which collapsed last summer, being shorn off horizontally by the water pressure about one-third of its height from the base.

The tank was designed under the direction of the writer by the Concrete-Steel Engineering Company, of New York, which also supervised its construction. The resident engineer was Mr. Charles F. Bornefeld. When the contract was advertised six bidders entered the competition, and the contract was awarded to the A. Mönsted Company, of Milwaukee, Wis., at a price of $24,335. Mr. A. D. Whipple was in charge of the work for the contractor. This type of construction is protected by United States letter patents, granted and applied for.

Trusses to Strengthen Plate-Glass Windows near Blasts

TO prevent large windows from being broken by blasting in the nearby subway excavation along Lexington Avenue, New York City, some of the plate glass has been reinforced by temporary trusses. Some full-height sheets of plate glass in store windows have been crossed by wires on both sides in vertical planes. They were connected to the window frames at the top and bottom and stretched tightly over two spreaders normal to the surface of the glass on both sides of the pane intermediate between the ends of the wire, thus forming queen-post trusses inside and outside of the window. The plate glass itself serves as the top chord of the truss. The spreaders were made of short pieces of wood with egg-shape bearings and rubber strips in contact with the glass, thus distributing the pressure and securing a good bearing. This method of reinforcement is said to increase the resistance of the window panes to the concussions when charges of dynamite are exploded in the subway.

MOTOR TRAFFIC INCREASE is well attested by the results of traffic census at DeKalb, Illinois. Mr. S. E. Brandt, secretary of the Illinois Highway Commission, in addressing the American Road Congress at Detroit, stated that in 1907 the motor-driven traffic was 5 per cent of the total, in 1912 50 per cent, and in 1913 60 per cent of the total traffic.

Emergency Handling of Garbage in Chicago

Disposal in Clay Holes after Expiration of Contract with Reduction Company

SINCE Oct. 1, 1913, garbage in Chicago has been mixed with ashes or other refuse and dumped into clay holes, because on that date the contract with the Chicago Reduction Company expired without any supplementary agreement having been consummated. In a recent address before the City Club Dr. George B. Young, health commissioner, explained how the emergency handling of garbage was progressing. His views on the matter are given below.

FLIES AGGRAVATE NUISANCE

He believes that garbage is of very minor sanitary importance. Corn is eaten off the cob and the cob is laid beside the plate. Five minutes later it is dumped in the can at the back door and it becomes garbage. There has been no inherent change in the composition of the corn cob or in its relation to the public health by that transaction. If the garbage is allowed to accumulate without disposal it will make a nuisance and indirectly become a menace to public health. If the situation is such as to permit or favor the access of flies, the garbage will immediately become an acute nuisance, and then, from being an acute nuisance, become an acute menace. Fortunately, the Chicago crisis did not come until the fly season was pretty well advanced.

Both in the press and in the many meetings which have been held to discuss this garbage question a good many things have been said about the garbage collections that are entirely unwarranted by the facts. On the morning of Oct. 1 the Department of Public Works and the Department of Health had to take charge of these collections together. The Street Bureau has co-operated with the Department of Health in entire sincerity. If the situation has been handled well, as it has been, said Dr. Young, it has been due to the entirely fair co-operation between the departments.

WHAT WAS DONE

This is what was done. Twenty men notified all the private collectors that until further orders they could collect garbage, mix it with ashes and other refuse and put it in certain selected spots—clay holes. The Street Bureau took off its garbage collection service and, using the teams thus released and employing a hundred or more additional rubbish-collection wagons, proceeded to make a mixed collection for a few days in certain localities. From time to time, owing to the failure of temporary drivers to cover the routes properly, there were collection delays in restricted neighborhoods, but from about the end of the first week, when the collections became better systematized, the collecting went on just as completely as had ever been the case. The city editor of one of the prominent papers sent out three men one day to get a story about the garbage piling up in the alleys. They spent the day on that job and had to abandon the story. They came back and said: "We can't find anything." That is the fact. "I went through a great many miles of alleys," said Dr. Young, "and I know it is a fact that, since I have known Chicago, the alleys have never been as free from scattered garbage and rubbish as they have been since Oct. 1."

Regarding dumps, Dr. Young stated that a dump has a characteristic odor entirely apart from garbage; even if no garbage goes into it, it has an odor that is unmistakable. That odor, however, does not ordinarily carry very far if the dump is properly maintained.

EMERGENCY TANKS

Concerning the emergency plant for treatment with acid in tanks, described in the Current News Section of the Engineering Record of Oct. 18, 1913, Dr. Young states that it has done about what was expected of it. There is not much smell, and what smell there is does not carry far. After material has been in the tanks for some hours—garbage is unloaded at night and the tanks emptied the next morning—men load the treated garbage on dump cars, pick the cars up with cranes and empty them in an excavation 30 ft. deep which is alongside of the plant. The men distribute ashes and rubbish—ashes almost entirely now—over the top of each day's accumulation to a depth of 1½ ft. While the work of covering it up is in progress one gets a certain amount of pig-pen smell if the breeze is strong. After it is covered up it does not smell. One gets some local odor there due to the fact that other garbage is being received. A little more than 300 tons a day are handled, which represents all the collection from twenty-two wards, and practically all of the collection that can be handled by water from the present two loading stations. The rest of the public collection, amounting to possibly 100 tons, which comes from territory too far south to be hauled to Chicago Avenue, has to be taken up as a mixed collection and taken out to various dumps on the South Side.

This is a temporary expedient, and Dr. Young says he has no defense to offer for it except that somebody had to do something and it was the best that could be done. It is a cold weather scheme only.

"As soon as we get near the border line of the fly season, as far as I am concerned, I will quit, because I don't want to undertake to do this during that season. Of course, if we could have in spring the same ash collection we have now we would carry the load along for a while until the collection got too big for us. But as soon as the spring really sets in the collections would get steadily larger, amounting in the summer to as high as 750 tons a day, an amount we couldn't begin to handle. Moreover, when the winter is over, the ash collection falls off so we wouldn't have anything to bury the garbage with.

"Furthermore, it is an expensive way of operating. We had to build this plant in a hurry and buy the stuff wherever we could and move it; we had to work men and gangs all night; we had to lift some of the bridges 14 or 15 ft. above their abutments in order to get the cranes under them. It has been an expensive operation, not on account of the materials used but on account of the large labor cost, but now we are going on with fair success."

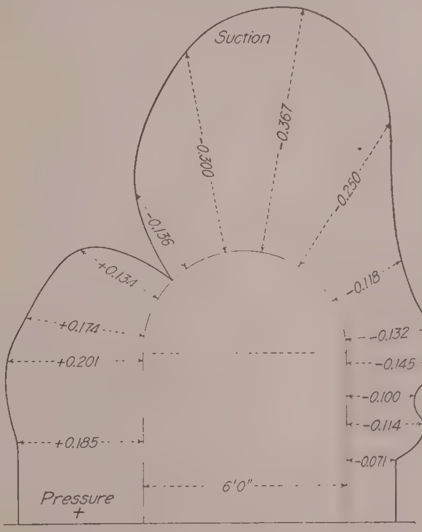
WATER RATES IN SEATTLE, WASH., have been reduced nine times since the city took over the Spring Hill plant in 1890. Rates for metered service are now 6 cents per 100 cu. ft. for quantities over 500 cu. ft., which is less than one-seventh the rate charged in 1890. The present daily consumption in Seattle, averaged for the year, is 35,000,000 gal., or 117 gal. per day per capita.

Wind Load on Buildings

Abstract of Paper by Prof. Albert Smith, of Purdue University, Presented Dec. 8 before the Western Society of Engineers

EXPERIMENTS on a roof of semicircular section of 6-ft. span and 10-ft. length, covered with tin, mounted on walls 5 ft. high indicate that the common assumptions in regard to wind load do not come very near actual conditions. Results of the experiments led the author to propose a conventional loading of the full-wind specification over 90 deg. of the roof.

After each set of observations the roof was lifted and 6 in. of the walls were taken off. At the middle section of the building ½-in. holes were bored about 1 ft. apart in walls and roof, the row extending from ground to ground. In the roof the holes had a short nozzle soldered on the inside. Tubes of rubber and glass led to a pressure-registering instrument consisting of a series of inclined glass tubes, one end of which was connected to a small reservoir and the other end to the tube from the holes. The gage tubes were mounted in a frame, one over the other, with a scale in the center. Photographs were taken of the meniscus to obtain simultaneous readings on all the gages and at the same time that wind velocity observations were made, 30 ft. to the windward side with a Pilot tube, which had been calibrated with a thin plate. Kerosene was used in the glass tubes and reservoirs. The reservoirs were placed in sloping rows on the back of the frame so that when the whole instrument was tilted ¼ in. in 10 in. a horizontal plane passed through the center of any tube at the middle would also pass through the middle of the walls of the reservoir of that tube.



Wind Pressure on Model House

Figures in pounds per square foot. Wind blowing from left to right.

The point of reversal of wind load from pressure to suction varied from 25 to 50 deg., but the average of seventeen readings indicate the point is at 45 deg.

In applying the unit loads it was proposed to draw on the cross-section of the building a semicircle with the half span as radius, placing the center of this semicircle at such distance below the peak that the area of the cross-section of the building above the base of the semicircle is the same as that of the semicircle. The 45-deg. radii will then intersect the roof at the point of change in the loading units.

Analysis of Reinforced-Concrete Chimneys under Earthquake Stresses

Discussion of Maximum Stresses, Points of Breakage and Formulæ for Calculating Principal Dimensions of Chimneys

By J. ALDEN GRIFFIN
Member Seismological Society of America

SIMPLE calculations for a reinforced-concrete chimney to resist wind and temperature stresses must occasionally be amplified to provide for earthquake acceleration. One can get a general idea of the effects of earthquakes on tall concrete chimneys by referring to the report of the State Earthquake Investigation Commission on the San Francisco earthquake of 1906, published by the Carnegie Institution of Washington, and from the publications of the Japanese Earthquake Investigation Committee, issued in 1900, in which there is an article by Prof. F. Omori entitled "Seismic Experiments on the Fracture and Overturning of Columns." Professor Omori states that brick walls of poor construction are slightly cracked with an acceleration of 300 mm (0.98 ft.) per sec.^{2} That plaster walls are cracked, old wooden houses are thrown down, but ordinary brick factory chimneys are not damaged with an acceleration of 900 mm (2.95 ft.) per sec.^{2}; that about one brick chimney in every four is damaged with an acceleration of 1200 mm (3.94 ft.) per sec.^{2}; that brick factory chimneys are broken with an acceleration of 2000 mm (6.56 ft.) per sec.^{2}; that all brick houses are very severely damaged with an acceleration of 2500 mm (8.20 ft.) per sec.^{2}; and that very severe collapses of structures occur with an acceleration of 4000 mm (13.1 ft.) per sec.^{2}.

Accelerations recorded in San Francisco in April, 1906, were approximately 13 ft. per sec.^{2} on soft, loose ground and about 5 ft. per sec.^{2} on good firm rock foundations. The writer, however, doubts the advisability or necessity of using an acceleration any greater than 6 ft. per sec.^{2} for a rational and conservative design, as no one would think of building a chimney on anything but a firm foundation, be it natural or artificial.

IMPULSIVE AND GRADUAL FORCES

Professor Omori in his discussion of the effect of an earthquake force says that difficulty may occur in deciding whether the application of the force is to be regarded as impulsive or gradual; that is, if the application of a force to an elastic body be so slow that the latter assumes the position of equilibrium without being thrown into vibration the force may be regarded as acting gradually, but if the application of a force to an elastic body be so rapid that it is finished in a time interval infinitely small in comparison to the period of the corresponding natural vibrations of the body, then the force may be considered as acting impulsively. For low chimneys and bridge piers the earthquake force may be considered as a gradual application.

Brick and plain concrete chimneys are very rarely broken at the base, but usually break a little above the middle, or approximately at two-thirds the height up from the bottom, as is evidenced by the table on page 118 of Professor Omori's report, where it is shown that out of forty-nine chimneys broken at the time of the Japanese earthquake of June 20, 1894, the range of the plane of fracture was from 0.24 to 0.94 of their heights and that the average of the forty-nine cases was 0.67 of the height. Only eleven chimneys out of the forty-nine cases had their top portions thrown to the ground, while thirty-eight of the broken portions remained at their original heights and presented the appearance of rotation about the fracture. This seems to substantiate the belief that a chimney under earthquake acceleration is weakest at a height corresponding to the center of percussion with respect to the base as a pendulum support, or at a point approximately two-thirds up from the bottom.

As earthquakes usually start with a slow acceleration and gradually reach their maximum, the chimney would fail theoretically at the weakest point first, the center of percussion, and thus the base section would never get stresses as large as those caused by the maximum acceleration, because the chimney, unless properly reinforced, would break at the level of percussion and thus leave a lesser mass with a lower height for the applied force to act on, which would make it unreasonable to assume the maximum acceleration acting at the base section for a plain concrete chimney, unless the acceleration were applied instantly, which is not very often the case.

MAXIMUM STRESS AT PERCUSSION LEVEL

As a slow rotating vibration or oscillation can be observed at the top of nearly every large concrete chimney under just an ordinary wind, while at the base there is no perceptible vibration, and especially in view of the fact that experiments have shown that the period of maximum motion of the chimney during an earthquake is a great deal longer than the period of maximum vibration of the earthquake, and since the height of the chimney is many times greater than the range or acceleration of the quake, it is reasonable to assume that the chimney actually acts as an inverted pendulum and the level of percussion really exists.

In view of these facts the writer is inclined to believe that an earthquake acceleration will cause a maximum stress at the percussion level and not at the base, and that, if the shaft is properly reinforced at the percussion level so that it does not fail there, the stresses at the base section, while small at first, will increase as the acceleration advances, but owing to the aforesaid differences in periods, etc., the writer is inclined to doubt that it would ever reach the maximum and favors, therefore, the assumption that the stresses, due to an earthquake acceleration, decrease with the height from the maximum at the percussion level to minimum at the base.

CALCULATING DIMENSIONS

The following approximation method is the one used to determine the principal dimensions of the chimney and then test it for stability against earthquake stresses as shown later, using for reference that valuable work, "Principles of Reinforced-Concrete Construction," by Turneaure and Maurer.

Having assumed or fixed the height and inside diameter that will give the desired commercial horsepower, assume a thickness of shell at the top of 4 in. for chimneys less than 8 ft. inside diameter; 5 in. for chimneys over 8 but less than 12 ft.; 6 in. for chimneys over 12 but less than 18 ft., and 7 in. for chimneys over 18 ft. inside diameter. The thickness given above should be increased 1 in. for every 28 ft. down from the top (if the chimney is to be built tapering), or, if cylindrical, carry the thickness at the top down to three-tenths the height up from the bottom and there provide an offset to permit an internal wall, standing free of the outside wall, to be constructed of a thickness approximately the same as that at the top of the main shell, with an air space of about 4 in. between it and the main shell. From the offset to the top of the foundation the main shell is increased in thickness so that it is 1.75 times the thickness at the top.

With this known, or rather assumed section, apply the following formula to at least three sections—that is, one at the base, one at the roof line and one at two-thirds the height up from the bottom. The following assumptions, symbols and unit stresses are those used for ordinary conditions, increasing f_c to 1000 lb. per square inch for the combination of earthquake, wind and dead-load stresses.

P_1 = wind pressure = 25 lb. per square foot of projected area
f_s = unit stress in steel at the steel line on the windward side, not to exceed 16,000 lb., preferably 12,000 lb. per square inch.
f_c = unit stress in concrete at the steel line on the lee side, not to exceed 500 lb. per square inch under wind and dead load; tension in concrete, nil.
$E_s = 30{,}000{,}000$; $E_c = 2{,}000{,}000$; $E_s/E_c = n = 15$
W = weight of chimney above section considered
H = height of chimney
h = height to center of gravity of portion above section considered
D = outside diameter of shell at section considered
d = inside diameter of shell at section considered
T = thickness of concrete shell
r = radius to center of wall
A_c = area of concrete at section = $2\pi rT$
A_s = area of steel at section
t = tension per square inch in windward side
g = 32.2 ft. per sec.^{2} acceleration of gravity
k = earthquake acceleration (in feet per sec.^{2}) = 6.0 ft. (see above)
P = earthquake thrust through center of gravity of portion above section considered
M_1 = overturning moment for wind stress = P_1h
M = maximum moment caused by earthquake action
p = percentage of steel
N = moment of resistance
R = radius of neutral core or kern circle = $(D/8)\,[1 + (d/D)^2]$
S = section modulus
e = eccentricty of resultant thrust
a = area of one reinforcing bar
q = number or quantity of bars.

Then to resist wind stresses:

$$M_1 = P_1 h$$
$$N = WD/2$$
$$S = 0.0982\,[D^3 - (d^4/D)]$$
$$t = (M_1 - N)/S$$

tA_c/f_s = total area of steel required.

Then $(tA_c/f_s)/a$ = number of vertical rods required in the section.

$$f_c = (W/A_c) + t$$

Then to resist earthquake stresses

$$P = k(W/g)$$
$$M = Ph = hk(W/g)$$
$$e = M/W$$
$$p = (qa/A_c)\,100$$

Now find value of e/r, and with the value of p, just found, find the value of m, and also the ratio of f_s to f_c from the diagram on page 408 in Turneaure and Maurer; then $f_s = f_c \times$ steel ratio, and $f_c = m\,(W/A_c)$; and while f_s and f_c are not the maximum extreme fiber stresses, yet it is very seldom, if ever, the case that if they are safe stresses the maximums would be unsafe; but in order to satisfy ourselves we can arrive at the maximum by either proportion or by the moments of inertia of the combined steel and concrete section:

f maximum (compression) =
$$(W/A_c) - (Mr_2/I)$$

f maximum (tension) $= (W/A_c) - (Mr_2/I)$

$$I = [n A_s \tfrac{1}{2} r^2] + [A_c \tfrac{1}{4} (r_1^2 + r_2^2)] = \tfrac{1}{4} A_c\,(2\,n\,pr^2 + r_1^2 + r_2^2)$$

where

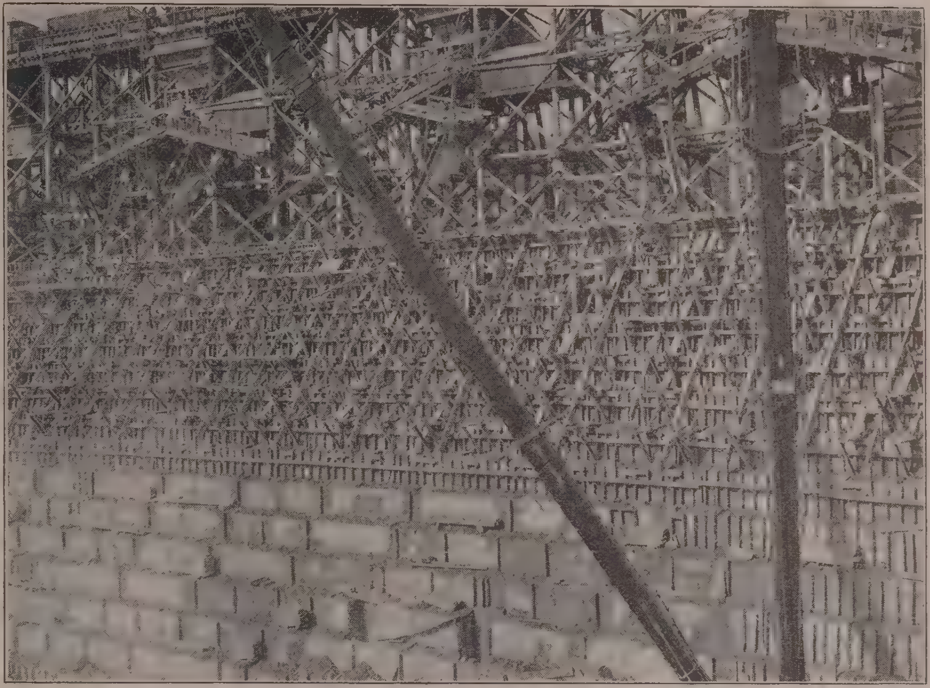
$$r_1 = d/2 \text{ and } r_2 = D/2.$$

Now by summing the unit stresses caused by dead load, wind load and earthquake stress, we will find the resultant unit stress, which should be within the aforesaid limits.

POSITION OF STEEL

The steel is best placed at approximately 0.75*T* from the inside face of the chimney shell in order to get as great a beam depth as possible. The size and vertical spacing should be determined for at least three sections by the formula for the collapsing pipes; only, instead of assuming a distributed or a concentrated load at any point on the chimney for the design moment assume the loads to act as a partially concentrated and a partially distributed load, distributed over a rupture width of, say, 48 in. measured vertically and keep the stress within 650 lb. per square inch in concrete and 20,000 lb. per square inch in the steel.

Having decided on the sizes and spacing it is only necessary to check the steel, both vertically and horizontally, against temperature stresses, which is best and very easily done by the formula and diagrams given in the work of Turneaure and Maurer.



Detail of Downstream Face of Dam, Showing Form Arrangement

Big Creek Hydroelectric Development

Rapid Construction of a 70,000-Horsepower High-Head Plant Located in the Inaccessible High Sierras of California

DIFFICULT mountain railroad construction, electric hoists operating over inclines having 75 per cent grades and building four concrete dams from trestles erected full height are some of the features involved in the Big Creek hydroelectric project started a year ago July last. The site is in the Sierra National Forest Reserve, 250 miles northeast of Los Angeles on Big Creek, a tributary of the San Joaquin River, at an elevation of 7000 ft. above sea level.

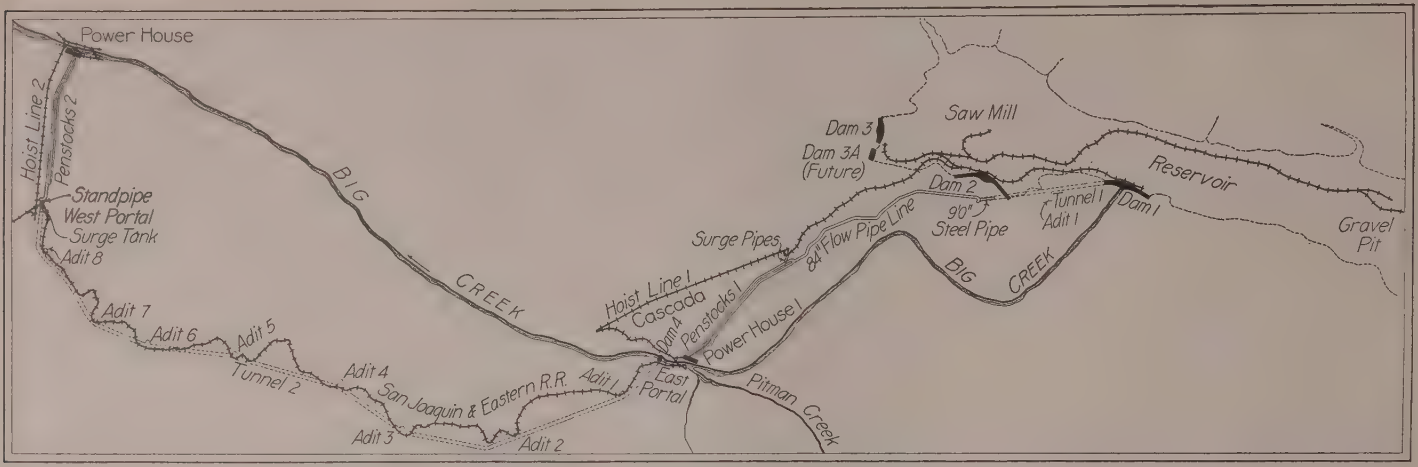
HEADS OF 2000 FEET

The snow-water flow from mountains rising to the 10,000-ft. contour is stored and is fed to two power plants, each utilizing in turn heads of nearly 2000 ft. in horizontal distances of 2 miles to the first station and 4 miles to the second. A brief description of the layout was given in the Engineering Record of Sept. 14, 1912, page 287, and a map showing the location of the various structures is shown herewith. Power is to be transmitted to Los Angeles at 150,000 volts for industrial, lighting and street-railway use, augmenting the present steam and water power plants of the Pacific Light & Power Corporation. The present development calls for two 17,500-kva units in each power house, but subsequently two more units of the same capacity in each power house can be supplied by adding 50 ft. to the height of the three existing dams. As constructed at present the Big Creek reservoir has an area of 1544 acres and a storage capacity of 53,000 acre-ft. of water derived from 88 sq. miles of watershed. When raised 50 ft. the reservoir will hold 110,000 acre-ft. Two more power houses further down the San Joaquin River have been projected, as well as further development of storage at Mammoth Pool, 10 miles above power house 2; but no details are worked out.

SITE INACCESSIBLE

Before beginning operations the site was one of the most inaccessible in the Sierras, being 56 miles by the construction railroad from El Prado, the nearest existing station on a branch of the Southern Pacific Railway, 18 miles from Fresno. From El Prado to Cascada, the main camp at power house 2, there is a rise of nearly 5000 ft. Construction of this road was very soon

Trestle 800 Feet Long and 135 Feet High, from Which Dam 1 Was Built with Twelve Mixers in Sixty Days



Map of Big Creek Development, Locating Dams, Tunnels, Pipe Lines and Power Houses

considered an absolute necessity, as the grades were such that with all the ten and twelve-horse teams that could be put on the road the plant would be several years in building. Orders for the railroad construction were given the engineers on Jan. 26, 1912, and 165 days later the last spike was driven. The actual construction was accomplished in five months and eleven days. Aside from the economy of rail transportation, storage of the 1913 flood waters could only be hoped for by rushing the 100,000 tons of material for the three dams at the greatest speed. The road follows the contours closely, thus giving few tangents after the foothills are reached at Auberry, 26 miles from El Prado. On this upper stretch ruling grades are 5 per cent and the curvature 60 deg. Two 60-ton geared, Shay type engines, capable of exerting a draw-bar pull of 25,000 lb. each, are required to haul the six-car trains.

Ordinary locomotives haul trains from El Prado to Auberry, where the geared engines pick up the load and make the run to the top of the incline at power house 2, or to Cascada at the foot of the incline at power house 1. Material is transshipped from these points to special "strong back" flat cars before being let down or raised over the inclines.

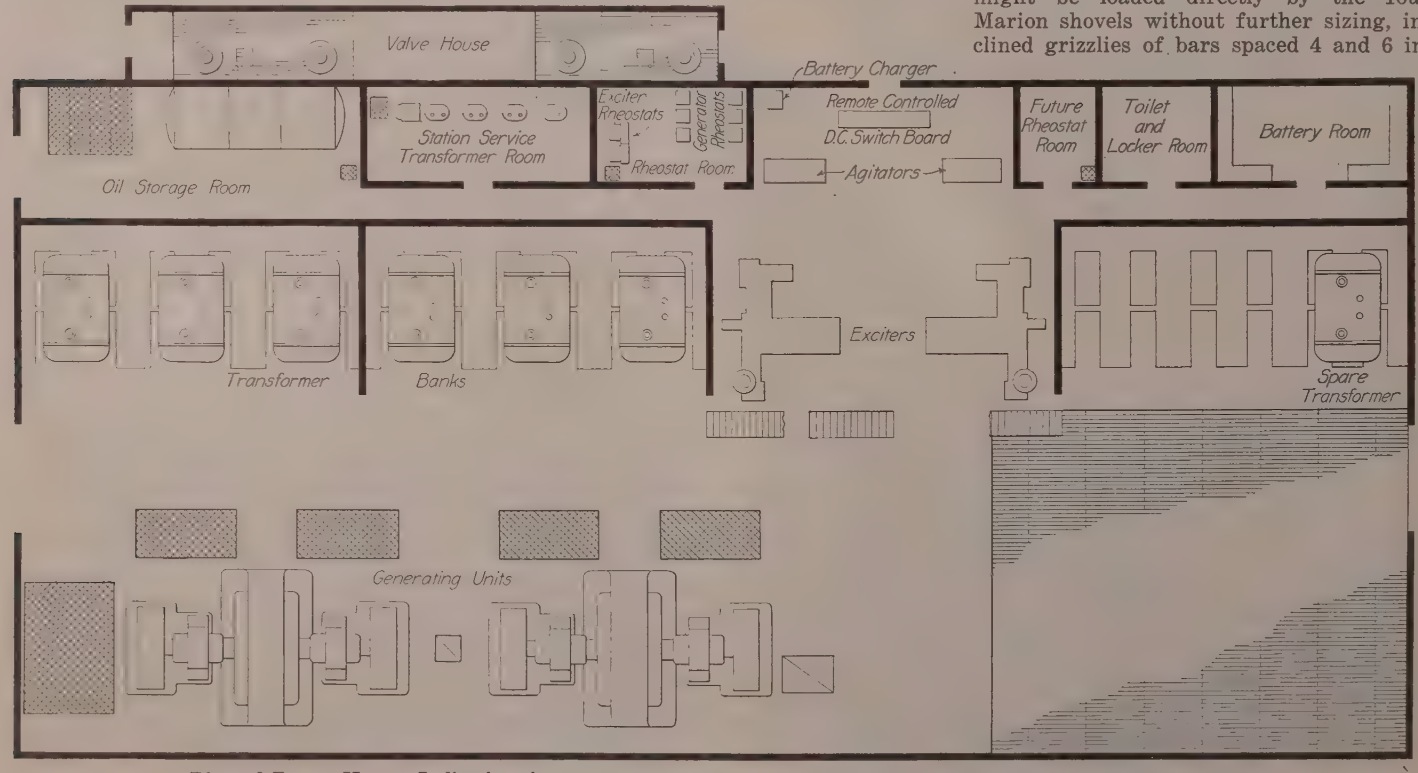
A wagon road 6 miles long from Cascada to the basin was constructed with maximum grades of 12 per cent; but it is little used except for passenger travel. No one is allowed to ride on the incline cars.

INCLINES

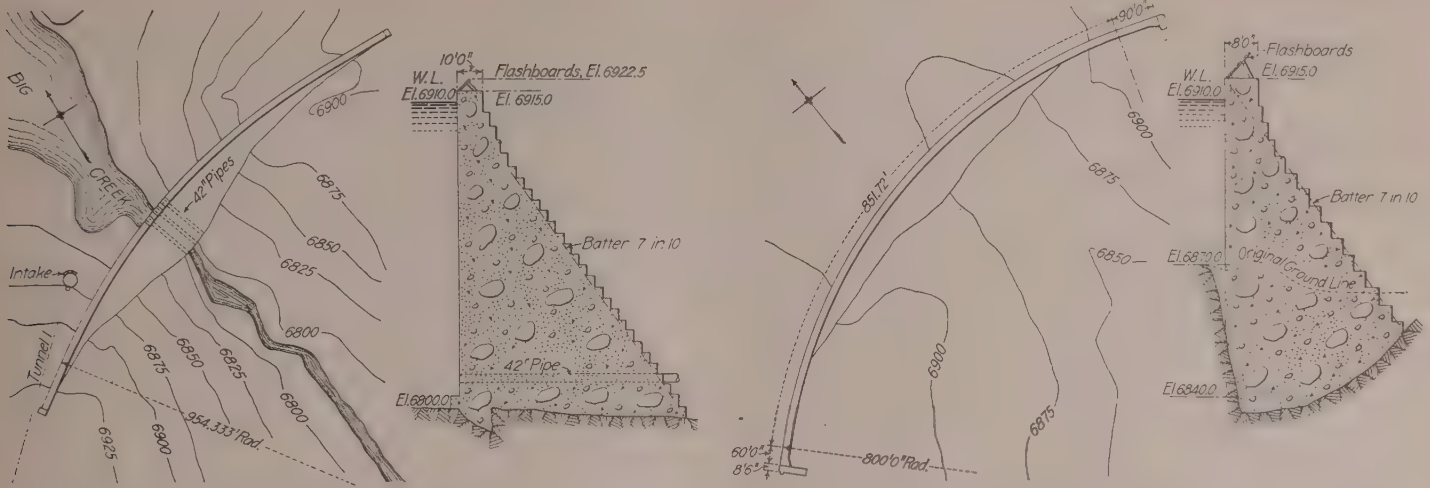
Each incline has a maximum grade of 75 per cent for short distances. They are each more than a mile in length and so located away from the penstock rights-of-way and the power houses that any accident from a car getting loose would not endanger the work. A lookout tower, from which a watchman, who has direct-signal communication with the engineer operating the mine hoists, and notes the safe travel of the cars, is located at the head of the grade. Each hoist, which is of special design built by the Willamette Iron Works from designs of the Stone & Webster Construction Company, is driven by two motors aggregating 300 hp. The maximum load handled by these hoists was a 42-ton locomotive. All loaded cars were secured to the 1⅜-in. Roebling plow-steel cable by bridles passing around the car. For empty flats the cable was passed over the top, fastened to the lower bumper and secured by a bridle to the upper bumper. On incline 2 the cars are prevented from tipping at a 30-deg. curve by lowering the outer rail and guiding the rope by means of a 10-in. pipe roller, 19½ ft. high, revolving on a 3-in. shaft set at right angles to the slope, which is 50 deg. at this point. The base of the shaft on which the pipe revolves sets on an upturned cone bearing.

BUILDING THE DAMS

All three dams forming the basin reservoir are of the gravity type and rest on blue granite explored by numerous diamond drill borings. Such additional stability as is given by the arched plan is an added factor of safety. The dams have an aggregate length of 2700 ft. and contain 120,000 cu. yd. of cyclopean concrete placed from mixers located on trestles built the full height of the dam before concreting was begun. The material bins and mixers were built below the deck of the trestles, which served as a bridge to carry the material trains, made up of standard-gage cars hauled directly from the sand and gravel pits located in the basin. So that the cars might be loaded directly by the four Marion shovels without further sizing, inclined grizzlies of bars spaced 4 and 6 in.



Plan of Power House, Indicating Arrangement of Equipment, and Space to Accommodate Additional Unit



Plan and Section of Dam 1

Plan and Section of Dam 2

Plans and Cross-Sections of Dams 1 and 2, Forming Storage Reservoir above Development 1

apart were built on top of the cars. Building the trestle the full height at dam 1 was necessary in order that the material for the other two dams might be excavated and piled near them before it became necessary to flood the pit by storing water back of dam 1, dams 2 and 3 being at natural depressions that are higher in elevation than the foot of dam 1, thus permitting construction to go on at these sites at the same time as the water rose back of the lower portion of No. 1. As a matter of fact, a temporary earth dam of 10,000 cu. yd. was constructed to keep the water from dam 3. This temporary dam was blown up when it became necessary to let the water into the area between it and dam 3. This procedure saved excavation, as the rush of water carried away the earth practically to the bottom of the 15-ft. height.

Dam 1, the highest of the three structures, spans the natural channel of Big Creek and has a top length of 800 ft., a maximum height of 135 ft. and contains 58,700 cu. yd. of concrete placed in sixty days by twelve mixers. The construction trestle, which was made up of bents, 16 ft. apart and in four 30-ft. lifts, was constructed in twenty-six days. From the mixers placed in the trestle a system of wooden inclined concrete chutes led directly to the forms. Inclined runways were provided along each chute, which was given a minimum slope of 16 deg. This same general scheme of handling concrete was carried out at each dam and also at the power houses. Three 2-yd. and nineteen 1-yd. Ransome mixers were used on the work.

On the average 1400 yd. of concrete were placed per day of two eleven-hour shifts, but the maximum day's work was 1800 cu. yd. The aggregate was hauled 4 miles from the pit, where two steam shovels loaded gravel and one handled sand. Nine locomotives were employed to haul the fourteen 12-yd. and thirty 6-yd. cars. Speed of placing depended on the capacity of the material transportation facilities. Each 8-ft. lift of concrete was given twelve hours to set before placing fresh concrete over it, which necessitated working the mixers in two batteries of six each.

Excavating the 81,000 yd. of rock to clear the foundation and handling the 2 and 3-yd. plums for the concrete were accomplished by nine stiffleg derricks having 125 and 140-ft. booms. The plums made up 15 per cent of the total volume.

During construction the water was handled through two temporary tapered sluices with cross-sections of 8 x 10 ft. at the upper end and 7 x 9 ft. at the lower end. When it came time to turn the river through the three 42-in. pipes stoplogs were placed next to the dam and also in the channels at the end of the piers, as shown in one of the drawings. The space between the two sets of stoplogs was then pumped out, and before the reservoir could fill to the top of the piers the heavy stoplog adjacent to the dam was calked tight. Concrete was then deposited in the sluiceway through inclined 4 x 4-ft. openings leading from the downstream face of the dam to the center and upstream end of the sluiceway. To care for shrinkage of the tapered bar of concrete a 2-in. grout pipe was left in place leading to the top of the newly placed concrete, and through the pipe 130 sacks of cement were forced in under 80-lb. pressure.

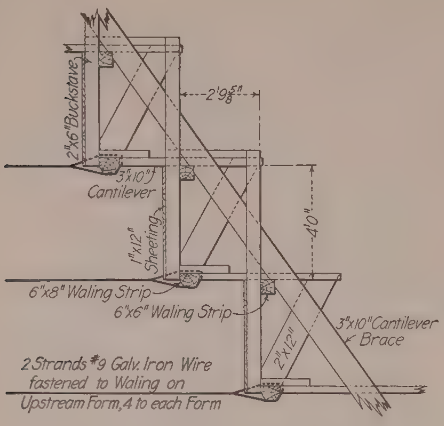
Entrance to the outlet tunnel is through a reinforced-concrete gate shaft, 20 ft. in diameter with 2-ft. walls. Three screens with the vertical bars 1¼ in. apart extend from top to bottom and are to be cleaned by motor-driven rakes. Over the tunnel portal is a 9-ft. Coffin sluice gate with double stems rising to the motor-operated stands in the concrete gate house. As a precaution against the possibility of abnormal stresses on the rack bars due to the shutting off of water by clogging of the screens two 4-ft. circular flap gates are provided 50 ft. above the invert of the tunnel.

GRAVEL PIT

It was intended to obtain aggregate for the present and future use from the site in the basin which would be submerged, but before the work was completed a suitable gravel bank was found above high water.

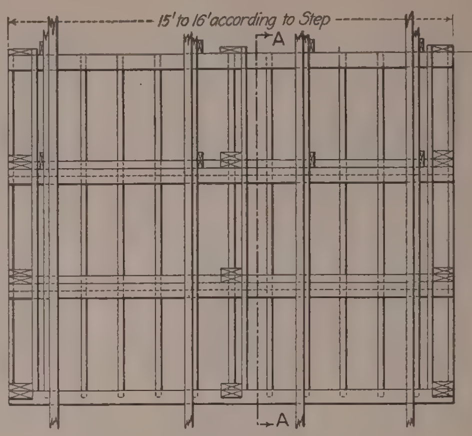
Although a 500-yd. gravel washery was installed, it was not needed for the present work, as the engineers were able to pick clean material as soon as the new pit was discovered. In this plant the cars dumped directly to eight hoppers holding 1000 cu. yd., delivering to a belt conveyor on one side leading to a 3-in. rejection grizzly. The cobbles go to the lake and the smaller

Big Creek Power House and Penstock 1 on Sept. 16, 1913



Section A-A

Forms for Downstream Faces of Dam



Back Elevation

Rear View of Forms for Dams

material travels on a belt up a 35-deg. slope 154 ft. to three motor-driven rotary screens, through which 1000 gal. of water pass in a reverse direction from the material. Bunkers for 500 yd. of washed material are provided.

LUMBER AND FUEL

Lumber for forms, tunnel timbers, trestles, ties, buildings and much of the equipment was obtained from the heavily wooded site of the reservoir. A sawmill with a capacity of 40,000 ft. per day was located in the basin, and, after cutting all timber available at this location, was moved to a permanent position near dam 2 above any present or future height of water. The mill was moved and again placed in operation in ten days' time. All timber over the overflow area was felled and then the logs were recovered from the slopes by a donkey engine mounted on a scow and towed by launch to the sawmill

Fuel oil, purchased on specification, was brought up the incline to the basin camp in the original tank cars, two of which could be unloaded by gravity at one time, to the 90,000-gal. circular tank. For the whole job 1,000,000 gal. were used, in addition to burning 8000 cords of wood in the cook houses.

POWER HOUSES

In most respects the power houses are identical, both being five-story reinforced-concrete structures about 100 ft. high. In No. 1 two General Electric generators are driven by an Allis-Chalmers waterwheel on each end of each shaft, while Westinghouse generators are installed in No. 2. The wheels in the upper and lower plant operate under 1940 and 1870 ft. effective head respectively. The head at No. 1 varies by 100 ft., due to the gradual emptying of the reservoir, but at the lower plant the pool back of dam 4 furnishes constant conditions. As water issues from the nozzles at a velocity of 3 miles per minute, the wheel pits are lined with ½-in. steel plates to protect the concrete.

Raising the 100 and 80-ton Cleveland cranes to place was done by jacking them up on cribs of ties. At No. 1 a falsework of piles spaced on 4-ft. centers was built up level with the elevation of the car tracks before unloading the cranes.

At No. 2 the site was covered with 25,000 cu. yd. of soil and débris, which were sluiced down the creek by two giants working under 250-lb. pressure obtained by leading in a supply of water from a point 4000 ft. upstream.

Towers 140 ft. high at both houses were used to distribute the concrete direct by chute to the foundation, walls and floors, but for the piers the concrete was wheeled from the elevator buckets. Tunnel spoil, rehandled by a steam shovel, was put through a Symons No. 10 gyratory at the upper power house. This crusher plant was located at the end of dam 4 and had a capacity of 300 yd. per day. Sand was obtained from the finer parts of the tunnel spoil and the finer aggregate from the rock crusher. At the lower plant a boulder field and quarry was located upstream about 600 ft. Hoisting engines pulled loaded Koppel dump cars to a crusher plant comprising an Austin gyratory and a jaw crusher, also Allis-Chalmers sand rolls taking 1-in. sizes. From the crusher the material was again loaded in dump cars of 6-yd. capacity and hauled by a hoisting line to a 250-yd. hopper over the mixer plant which was located on the hillside of the power house. An extension of this industrial track connected with the incline over which cement was brought in. To handle forms, lumber, built-up steel column cages and other material, a high-line cable was erected over the power house, the ends passing over tall guyed A-frames.

"Go-Devil" Laying Large Pipe

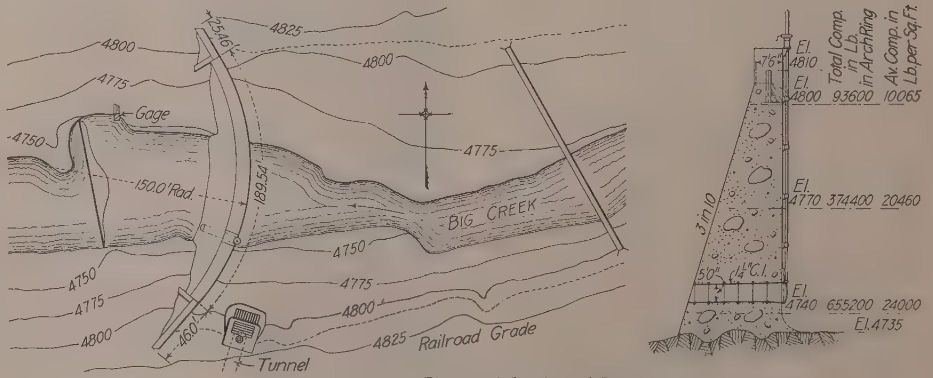
TUNNELS

Tunnel 1 leading from the reservoir is 12 ft. in diameter and 4190 ft. long. Tunnel 2, also 12 ft. in diameter, connects the pool back of dam 4 with the penstocks of power house 2, and is 23,026 ft. long. Both tunnels were driven the full size for the ultimate development. The engineers report satisfactory material, consisting of solid gray granite throughout with few fault lines, with the exception of one section of rotten rock, around which a detour was made. As the tunnels are not to be under much pressure, no difficulty is anticipated. The work is prosecuted from twenty headings at eight adits and four portals. A maximum of 95 ft. per day and 282 ft. per month at one face is the highest record. Usually with the eighteen holes drilled with 2-in. steel on the circle and with six pulling holes the average pull is 6 ft. Twenty-two men are assigned to a heading on eight-hour shifts. Muck is removed by mules, as the longest section between adits is only 3706 ft. No. 40 motor-driven Sturtevant exhaust fans are installed at every adit and a relay fan is placed every 1000 ft.

In the three compressor plants are five Ingersoll-Rand units, each having a capacity of 1150 cu. ft. per minute, and three units of 750 cu. ft. capacity made by the Chicago Pneumatic Tool Company. Air is distributed through 15 miles of 4-in. main line. On the whole work were forty Sullivan, sixty Chicago Giant 3¼-in. drills and twenty-five Jap drills for trimming.

FLOW LINE AND PENSTOCKS

Beginning 400 ft. back in tunnel 1, a 9-ft. steel pipe is concreted solidly into the tunnel. The joints of this pipe were riveted outside the tunnel and the pipe hauled in on greased rails. From the portal to the brow of the hill an 84-in. riveted steel line, 6884 ft. long, furnished by the Willamette Iron Works, is laid in open cut on concrete saddles spaced on 35-ft. centers. At curves reinforced-concrete anchors extend over the top of the pipe. Since the line is to be entirely covered with backfill, no provision is made for expansion.



Plan and Section of Dam 4

Details of Dam at Head of Development 2

In wet ground drain tile is laid under the pipe to prevent floating.

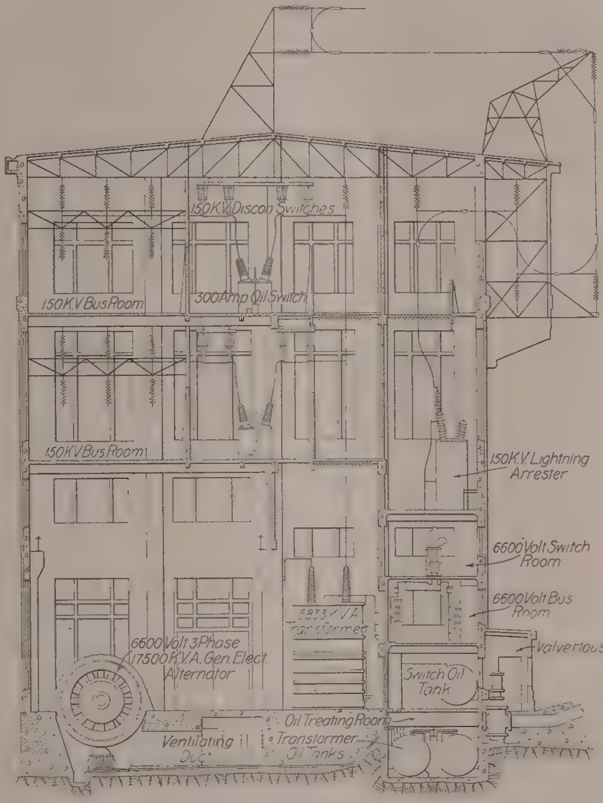
To expedite laying the pipe a standard-gage track was placed in the trench and the sections brought in on flat cars. A hand-operated 24-ft. boom on a platform 42 ft. long, straddling the pipe and resting on greased frames of 4 x 4-in. timbers, raises the pipe from the flat car, which is drawn forward by the locomotive. Then the section of track under the pipe is loaded on the car. The pipe is then lowered to place on blocking and jacked into line and grade. A rivet is knocked out of the pipe and the frame on which the "go-devil," as it is called, rests is bolted to the pipe to keep the track from spreading and to hold it in line, most of the weight being carried on blocks. With this rig an average of 400 ft. of pipe was laid per day, the maximum being 500 ft.

Hot air and gases were removed by a motor-driven exhaust fan having two blades nearly the diameter of the pipe. At first the air was forced into the line, but too much draft was produced for comfort.

Just before passing to the steep portion of the line, on which are maximum grades of 75 per cent at station 1 and 80 per cent at No. 2, the pipe is branched as shown on the general drawing. At station 1 a 24-in. surge pipe is laid 1000 ft. up a sidehill to an elevation 30 ft. above the level of water in the reservoir. At this point the two 42-in. bell-and-spigot riveted-joint penstocks proper start and are gradually reduced in size to 32 in., 700 ft. above station 1 and 36 in. 100 ft. above No. 2, until the required metal gets 1 3/16 in. thick. From these points each line is branched to 26-in. pipes, which lead to the reducers entering the 24-in. hydraulically operated Coffin gate valves near the power house. All of the lap-welded pipes were furnished by Mannesmannsröhren-Werke, Dusseldorf, Germany, and have flange or riveted bell-and-spigot joints. Alternate joints are supported by an anchor extending over the pipe or by a saddle.

As the penstocks for No. 2 lead directly from the tunnel portal a surge chamber, 32 ft. in diameter and 110 ft. high, was built in the solid rock 250 ft. back from the mouth of the tunnel. The concrete shell, which is reinforced to take the stresses, rises 20 ft. above the natural surface. It is not intended that this chamber shall overflow, as the top is 30 ft. above the surface of the water during operation and 10 ft. above the pool back of dam 4.

The Stone & Webster Engineering Construction Company, of Boston, designed and is constructing the Big Creek project for the Pacific Light & Power Corporation, for which Mr. E. R. Davis is manager. For the construction company Mr. S. L. Shuffleton is general manager and chief engineer in charge of the Pacific Coast territory. Mr. F. M. Thebo is superintendent, Mr. R. C. Starr, assistant superintendent, and Mr. W. D. Shannon, resident engineer at Big Creek.



Sectional Elevation of Power House at Big Creek

New Waterworks for Springfield, Illinois

Driven Wells, Instead of Filter, Chosen for Sake of Economy

LAST October Springfield, Ill., now a city of 55,000 people, dedicated a new pumping station housing a 10,000,000-gal. Holly self-contained vertical, triple-expansion, flywheel type of engine. Normally the engine works against a total head of 277 ft., practically doubling the pressure heretofore available.

NEW DRIVEN WELLS

Water has been obtained from the Sangamon River, but the supply is now being changed over to driven wells sunk in sand and gravel strata to a depth of about 50 ft. It is planned to have ultimately six small stations of 1,500,000-gal. capacity each. At present the average consumption is 5,500,000 gal. daily. Three units are already in operation. Water is raised to a flow line laid 3 ft. underground at these substations by American motor-driven centrifugal pumps. The wells are located in groups 300 to 1000 ft. apart in a 250-acre tract extending a mile from the main station, where the water is received in a pump-suction well.

Notwithstanding the drought of the past summer, when no soaking rains fell after April, it is stated that three wells maintained the supply for the city until October. At that time a small quantity of river water was required to make up the shortage.

Wells rather than a filter plant were the economic choice at Springfield. Filters were estimated to cost $150,000 and wells about $35,000. The corresponding annual maintenances were estimated at $15,000 and $5000.

Analyses of the well water show, in parts per million, turbidity, 2; color, 35; residue on evaporation, 273; chlorine, 1; oxygen consumed, 1.2; free ammonia, 0.156; albuminoid ammonia, 0.054; nitrites, 0.003; nitrates, 0.20; alkalinity, 208; bacteria per cubic centimeter, 6.

After steady pumping the water is drawn down from the normal level to such an extent that any single group of wells is estimated to effect a cone with a top radius of about 600 ft. The wells are equipped with No. 40 cut Cook strainers. They are sunk by the use of sand buckets and are cased with 12-in. wrought-iron pipe.

PUMPING STATION

The new pumping station is a steel-frame structure with brick walls and a concrete substructure, entirely fireproof. The roof is of concrete and the steel sash occupies about 30 per cent of the wall area. The building is a two-story structure with the main engine room, 140 ft. long by 50 ft. wide, served by a 20-ton Pawling & Harnischfeger electric crane. Space is provided at one end for electric generators for the municipal lighting plant, in addition to provision for two future pumps. Electricity for the substations is generated here by one direct-connected generator, 125-kw capacity. Another unit is to be installed soon.

The pump pit is 24 ft. deep below the ground level and 50 x 85 ft. in plan. The reinforced-concrete walls are 30 in. thick with footings 6½ ft. wide, except under the pilasters, where they are 10 ft. wide. All concrete was waterproofed with a colloidal hydraliquid. Under the 400-ton pumping engine is a foundation slab of concrete, 19 ft. wide by 27 ft. long and 6 ft. deep, resting on piles driven to hardpan. These piles are spaced about 3 ft. on centers.

Materials in the building are: 850,000 brick, 90 tons of steel and 2044 cu. yd. of concrete. The cubical content is 430,000 cu. ft. and the floor surface, 16,000 sq. ft.

A new boiler plant also has been installed, consisting of three Springfield and Heine water tube boilers having a total capacity of 1100 hp, but capable of 25 per cent overload. Usually one boiler carries the station load.

A new brick stack, 7 ft. in diameter and 152 ft. high, rests on concrete base having a 30-ft. spread resting on sand and gravel. It was constructed by Kellogg & Company, of New York.

The improvements carried out by the city under the direction of Mr. Willis J. Spaulding, commissioner of public property, are new mains, $75,000; metering entire city, $40,000; new pump, $52,000; new station building, $55,000; steam plant and stack, $20,000; underground development, $20,000, and sundry equipment, $20,000. The W. N. Allen Sons Company was the contractor for the station building. The wells are being driven and the substations are being built by day labor under the direction of the engineers of the water department.

A HIGHWAY SUSPENSION BRIDGE span 451 ft. long, with a roadway 9 ft. wide in the clear, has just been erected at a height of 250 ft. above the water at Bulkley River Gorge, New Hazelton, B. C. The cables, 2½ in. in diameter, have an ultimate strength of 350 tons and are anchored to 150-ton blocks of concrete. They are suspended from wooden towers 65½ ft. high and are stiffened by steel lattice girder handrails.

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Purchasing City Supplies

Second Portion of Report by Elihu C. Church on Organization and Administration of Supply Bureau, Department of Water Supply, New York

THE scope and duties of the newly organized Bureau of Supplies of the Department of Water Supply, Gas and Electricity, New York City, as outlined in a recent report by Mr. Elihu Cunningham Church to Commissioner Henry M. Thompson were dealt with in an article in the Engineering Record of Jan. 3, page 21. The facts regarding the organization and administration of the bureau, which form chapter 2 of the report, are given below.

Conditions Governing Reorganization

The first problem in the organization of the Bureau of Supplies concerned the internal affairs of the bureau itself, the object being to systematize and direct the work so that it might be done correctly at the least cost. The Bureau of Supplies purchases, inspects, stores and issues all materials used by the department and lets all contracts for work done and services rendered, thus dealing with the most vital functions of a going concern whose operation could be neither stopped nor delayed. All changes had to be so made that they would not interfere with the work. The pumping stations had to have coal and oil even though the specifications for coal and oil were not perfected; nor would the lack of a general stores control system have excused withholding supplies from a pumping station simply because the need for them had not been investigated.

Another element which complicated the situation was the fact that the time for carrying the reform into effect was limited, so it was necessary first to remedy those matters which involved the largest expenditures or the greatest amount of waste.

The work was mapped out, the various duties being classed according to their nature into purchasing, inspecting and storage and issue of supplies. A diagram of the organization was prepared and the duties of the personnel assigned in accordance with these functions.

Standardization of Procedure

Conditions and procedure were next standardized so that work was no longer done in a haphazard manner or left to chance. All steps in every activity of the bureau were studied and instructions were prepared showing: What work was to be done; how the work was to be done; where the work was to be done; when the work was to be done, and who was to do it.

These standard practice instructions systematized and simplified the routine of the office so that it could be carried on by the fewest possible number of employees and in the least time. To instruct employees concerning what they have to do, and how they are to do it, not only prevents conflicts of authority, but fixes responsibility and shows whether or not the work is being attended to.

The routine has been made as simple and as flexible as possible. The magnitude of the business makes it impossible for the men at the head to keep familiar with all details; subordinate officials are trained to assume responsibilities within their grasp. Though the line of authority is strictly maintained and orders are given in accordance therewith, all employees are expected to co-operate and furnish information and assistance to one another whenever possible.

The philosophy of the arrangement has been, first, to standardize the routine work so that it becomes practically automatic; second, to place responsibility for details with men having sufficient time and first hand knowledge of the facts to pass upon them; third, to release the men, who by reason of experience, knowledge and skill, are at the top of the bureau, from functional activity so that they are free for the larger creative and administrative duties.

At the beginning the departmental units in the various boroughs obtained prices for supplies separately, and in order to obtain greater efficiency, this work was concentrated in one central office. This resulted in a slight reduction in the force, tending to unify the organization and give better control. The values of centralization, however, were not alone brought about by locating all employees doing similar work in one office; the main advantage lay in the opportunity to improve upon the old methods in which requests for purchase of supplies were prepared in the various boroughs without knowledge of standards or of stock possibly on hand elsewhere; and in which these individual requisitions were handled separately, and consequently uneconomically.

The concentration of goods on hand was next undertaken and storerooms were fitted up at central locations where supplies could be conveniently delivered, promptly inspected and properly stored, issued and accounted for.

"Indispensable Men" Not Wanted

Training the employees was next undertaken. It is all very well to study conditions and develop the most scientific and efficient procedure, yet without the intelligent co-operation of the men required to carry it out, progress will be slow. They must be instructed in their duties—they must have explained to them in detail what is expected to be done and how and when and where and by whom. They must be "coached" with the same care and thoroughness that is used with the members of a professional ball team, a college crew, or the detail working of a coast defense gun. It calls for much persistency, for old habits must be broken before new ones can be acquired, and the men must be tried at this and at that to see where they best fit in, as a man can only do his best work when adjusted to the organization. Alas, some men do not appear to be much good anywhere. Military discipline is very necessary but most difficult to obtain where the man in charge lacks the power of the "bounce."

It is necessary that there be no "indispensable men." Such ones are the most dangerous units in any organization, for sooner or later they are taken sick or die, or get a better position elsewhere, and the work suffers since they were "indispensable," and there is no one prepared to take their place. There should be one or more men regularly trained as "understudies" for every position.

Only the most incompetent object to this policy after it is explained that the "indispensable" man stands in his own light as regards promotion and advancement, for with no one fitted to take his place he must perforce be left in it, and some other man given the coveted vacancy higher up, when such occurs.

Besides making the force adaptable, such training tends to make a man do his own particular duties better and more intelligently since he sees their relation to the work as a whole. It gives him interest and it enables him to suggest improvements of value where other branches of the work touch his.

No Roll-Top Desks

The old conditions under which the office work was carried on were most unsatisfactory. The clerks faced a low railing which separated them from the space where the public came to make inquiries and transact business. This resulted in constant interruption of the work. The office arrangements were shifted, one of the changes being that the desks were turned away from the public and faced toward the wall. Further to save the time of the higher paid clerks, all telephone calls and all personal inquiries of individuals were first answered by a boy who found out what was wanted; and in the majority of cases was able to attend to it himself without interrupting the other men. Wherever roll top desks were found, flat top desks were substituted, and four-legged cane-bottom chairs took the place of the swivel and padded variety.

The space allotted to the storage of goods was fitted up to best serve the purpose.

System and standardization have been extended to all devices used for keeping the office records; and the new forms, ledgers and cards that have been introduced are a vast improvement over the miscellaneous collection of papers which they superseded.

It is clear that all business must keep records of its activities and transactions, but beyond that point ideas are often vague or at variance. The nature, extent and character of the statistics best suited to the problems in hand have received much study. So truly do circumstances alter cases that any attempt to take the forms and blanks of some railroad or other corporation and graft them bodily upon a different business is foolish. It is as if the Republic of Hayti should solemnly adopt the Revised Statutes of the United States and enact them as the law of their land, expecting in consequence immediately to enjoy a similar government. Improvements are not accomplished that way. Even with the best of systems, specially designed to meet the needs of any business, the personalities of the men in charge are the governing factors.

A great deal of the work has been pioneering, for there is but little information available to guide in formulating the philosophy underlying such an undertaking. Still less is there to guide one when it comes to the carrying of it out. Many a promising experiment gave unsatisfactory results. But then the Chinese Navy is the only one that never has any accidents—for it never goes to sea. Mistakes often occurred, as was to be expected where new methods of doing business were being developed, but the same mistake seldom occurred twice.

Air Seasoning of Timber

Effects as Deduced from Extensive Records, of Time of Year, Kind of Wood, Manner of Exposure and Other Conditions

PROPER seasoning of timber is conceded to have an important bearing on the strength and durability of the timber, whether or not it is subsequently treated. Data as to the right length of time for air seasoning, heretofore scattered and incomplete, have been assembled by Mr. William H. Kempfer of the Forest Products Laboratory at Madison, Wis., who presents in the November "Bulletin" of the American Railway Engineering Association the results of records kept on many lots of timber of different kinds, cut in various localities and seasons. From the tables and curves given Mr. Kempfer draws conclusions which are abstracted below.

CLIMATIC CONDITIONS

The accelerating effect of warm, dry weather on the rate of evaporation and the retarding effect of cold or wet weather were seen very plainly in those seasoning tests which were started at different times of the year, and also in tests where the weighings were continued from one summer through the winter into the succeeding summer. Timbers which had become fairly dry ceased to lose moisture, or even gained weight, during the wet or cold, damp weather; but timbers cut in the unfavorable periods showed a moisture loss during subsequent unfavorable weather, and by the time of the warm, dry weather they had so far seasoned that the rate of loss was fairly constant throughout both periods.

The effect of climatic variations in the different places where the tests were made was less, on the whole, than the effect of the changes in a given locality throughout the year. Each locality had its favorable and its unfavorable periods. Although direct comparisons of climatic effects cannot be made because different species were studied in the different localities, the effect of hot, dry and long summers is marked.

By considering the effect of time of year on rate of seasoning, timber may be cut at such time as to obtain either slow or rapid drying. When timber is cut in one part of the country to use in another part, climatic conditions should also be taken into account. Thus in the case of a timber-treating plant drawing supplies from different parts of the country, it would be worth while to consider whether the timber should be held for seasoning at the plant or in the locality where cut.

SPECIES AND FORM

Variations in the rate of seasoning among species may be due to differences either in moisture content or in permeability of the wood. Of two pieces of wood differing in moisture content, other conditions being equal, the one with the more moisture will dry the more rapidly, and in a comparatively short time both pieces will reach about the same condition. This rule does not apply strictly between different species, but with conifers the usual variation between the species does not seem sufficient to necessitate separate treatment.

Sapwood of the conifers contains, as a rule, much more moisture than does the heartwood, and a difference in the proportion of heartwood and sapwood in two timbers of the same species accounts for a large part of the difference in moisture content. But sapwood loses moisture more rapidly than the heartwood, and this tends to equalize the time required for the two pieces to become air dry. Furthermore, so far as the data presented afford a basis for comparison, ties of different coniferous species, all seasoned under the same conditions, usually differ much less in time required to become air dry than in amount of moisture lost.

The size of the piece influences the time required for seasoning, because it affects the relation of the volume of a timber to its surface area and the distance which the moisture on the interior must traverse to escape from the surface. This influence, however, is not as great as might be expected. Shortleaf pine in 5 x 8-in. beams contained only 3 per cent less moisture after fifteen months' seasoning than those 8 x 12 in.; 7 x 9-in. redwood timbers contained 3 per cent less after three years than those 8 x 16 in., and the 3 x 14-in. size contained 3 per cent less than the 7 x 9-in.

MANNER OF EXPOSURE

The extent to which timber is exposed to atmospheric influence has an important bearing on the evaporation of moisture from its surface. The exposure is affected chiefly by the manner of piling the timber. If weather conditions are favorable isolated piles permit rapid seasoning, however closely the ties are stacked, but if the piles themselves are crowded together the influence of the form of pile undoubtedly becomes more pronounced.

The combined effect on the rate of seasoning of close piling of ties and retention of their bark is indicated by tests made on hemlock. Ties that had been piled solidly with the bark on weighed 40 lb. per cubic foot at the end of one year. The average weight of peeled hemlock ties in various isolated piles seasoned for one year ranged from 36 to 38 lb. per cubic foot and was usually less than 37 lb.

Attempts to determine the effect of the position of piles with regard to wind direction showed negligible results.

Site has an important effect on seasoning. Chestnut poles in Maryland which were fully exposed to sun and wind lost 25 lb. per pole more in ten months than others partly protected by a hill and surrounding trees; and poles skidded over dry ground lost 35 lb. more per pole in eight months than others skidded over ground which was wet and covered with rank vegetation.

In tests to determine whether seasoning of timber may be facilitated by soaking it in water, it was found that timbers which had been soaked for short periods, upon removal from the water, lost the extra moisture so fast that they soon reached practically the same condition as similar timbers not immersed. Whether the soaked timber ultimately reaches a lower moisture content is still open to question.

DETERIORATION WHILE SEASONING

Complaint is often made that timbers of certain species, such as the soft pines, the gums, beech and maple, will decay before they will season. It is believed that this can be prevented usually by piling the timbers so as to dry rapidly. The tree should be barked as soon as felled, and the timbers piled openly. Injury by insects may be prevented in the same manner.

While quick seasoning prevents injury by decay and insects, it is not always necessary nor desirable. Timber cut and set drying in hot weather checks more seriously than in cold weather, and sometimes becomes "case-hardened" and very resistant to preservative treatment. Timber cut in the late autumn or winter seasons more slowly and evently; if peeled and properly stacked, or skidded off the ground, it dries enough before warm weather to resist attack by insects or fungi. But whatever the time of cutting, careful attention is needed in piling the timber, either more openly or more closely, according as local climatic and other conditions are found to require.

It is frequently stated that wood cut during the winter when the "sap is down" is of better quality or more durable than that cut when the "sap is up." These effects must be attributed very largely to external conditions rather than to internal conditions of the tree before it is felled. Moreover, contrary to popular belief, a tree contains as much sap in winter as it does in summer.

DEGREE OF DRYNESS ATTAINABLE

The term "air dry" has heretofore been used as a matter of convenience to indicate the lowest moisture condition reached by the various timbers. In most cases, further losses would have occurred if the tests had been continued. Such losses, however, especially with large timbers, are so gradual after the greater portion of the moisture has been evaporated that it is impossible to fix any particular moisture per cent to be designated "air dry."

The drying of wood is accompanied by a shrinkage of its volume which begins usually when all water has been evaporated from the cell cavities, and the cell walls themselves begin to dry out. When this condition is reached, the moisture content is, as a rule, less than 30 per cent. The moisture content in a large stick is not evenly distributed, however, and the outer portions dry first, so that some shrinkage occurs almost as soon as seasoning begins. Partial air seasoning has very little effect in preventing the subsequent shrinkage of timbers, and complete air seasoning is not sufficient if the wood is later to be subjected to further drying, as by use in artificially heated structures. Shrinkage is nearly twice as great tangentially as radially. Longitudinal shrinkage is so small that it may be disregarded.

ENGINEERING PERCENTAGE COSTS of carrying out work in the Sanitary District of Chicago are 39 per cent for 1911, when $360,000 was expended; 31 per cent in 1912 for $576,000 worth of construction, and 31 per cent for the first nine months of 1913, when work to the value of $960,000 was carried out. These engineering percentage costs, which are given in a report by the chairman of the finance committee, include such items as maintenance and operation of bridges, pumping stations and other items of general work done for other departments, which is not strictly chargeable to construction. Deducting these charges, the relative percentage costs for the three periods are 21.8, 14.1 and 8.8 per cent respectively.

Screwjacks in Place for Raising Circular Bin Forms

Girard Point Grain Elevator

Million-Bushel Fireproof Terminal Structure Equipped with the Most Modern Devices for Rapid Transshipment of Grain

RAPID rail-to-water transference of grain—with 1,000,000-bu. storage capacity as an equalizer—is the purpose of the fireproof grain elevator recently completed at Girard Point, Pa., for the Girard Point Warehouse & Elevator Company. The plant is located near the mouth of the Schuylkill River, 2 miles below League Island Navy Yard, where docks and smaller terminal elevators already exist. The bulk of wheat handled during the busiest season will originate in the Canadian Northwest and be shipped over the lake route to Buffalo, thence by rail to oceangoing vessels at Girard Point.

FEATURES OF DESIGN

Features in the design furthering the fast transshipment of grain are the large capacity and flexibility of the receiving and shipping arrangements. There is a six-track shed, four cars long, permitting the unloading of twelve cars at once, and a shipping gallery capable of loading an ocean steamer, 650 ft. long, at the rate of 60,000 bu. per hour.

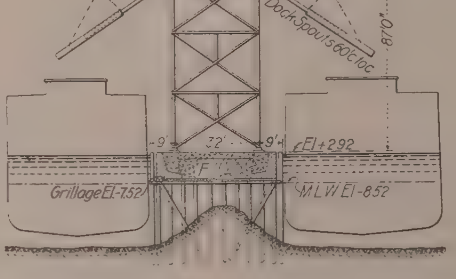
In general the plant consists of a working house, trackshed, storage and conveyor gallery, pier, power house and drier. Grain is received in the trackshed receiving pits, and after unloading is carried to one of four receiving elevator legs and elevated to the garner over a receiving scale, from where, after weighing, it is spouted to bins in the working house for cleaning or shipment to vessels, or is carried on a conveyor belt to the annex for storage. Shipping facilities to vessels are provided by four belt conveyors from the working house to the pier. It is possible to weigh 100,000 bu. of grain ahead and ship it without re-elevation. The four receiving legs and three shipping legs each has an elevating capacity of 15,000 bu. per hour. While the shipping legs may not be used for receiving grain, all receiving legs may be used for shipping purposes or transferring grain.

WORKING HOUSE

The working house is a reinforced-concrete structure, 62½ ft. wide, 94½ ft. long and 202½ ft. high above the pile cutoff. It is divided into a basement, first story, bin storage and cupola. The basement provides room for the elevator boots, spouting conveyors which run in the trackshed, storage annex, drier and electrical motors and power-transmission machinery. The first story is 20 ft. high. In it is located the discharge spouts from the working-house grain-storage bins and the loading end of a system of four belt conveyors for shipping grain to the vessels.

Above the first story are the storage bins, twenty-four concrete tanks of 241,000-bu. total capacity, arranged in four rows of six each. They are 13 ft. in diameter on the inside, 74½ ft. high and have 7-in. reinforced-concrete walls. Both circular and interstice bins are used for storage. Above the bins is the cupola, a four-story structure, on the bin floor of which are five 36-in. belt conveyors running out to the storage annex for transferring grain from the working house to the annex. There is also a 42-in. reversible transfer belt for transferring grain longitudinally. Under the scales on the distributing floor are ten distributing spouts, each of 22-ft. radius, for discharging grain from the scales to fixed spouts and conveyors below. In the scale story there are four 2,000-bu. and six 1,400-bu. Standard hopper scales, each having a garner above. In the machinery story are all of the leg heads with the exception of the screenings leg. They are all driven by Plymouth rope drives from Allis-Chalmers motors located on the floor below.

The trackshed is a reinforced-concrete structure, 120 x 144 ft. in plan and 23½ ft. high at the low point of the roof. It has provisions for six tracks with twelve unloading pits. Steel receiving hoppers are arranged in four batteries of three each and are equipped with interlocking devices so that only one hopper gate may be opened to feed one conveyor at a time. Each battery discharges to a 36-in. belt conveyor leading to the receiving legs and four steel boot tanks in the working house. These steel boots, made by the Treadwell Manufacturing Company, are watertight and extend the full width of the trainshed between concrete walls. Their tops were fixed, 3 ft. 8 in. above the basement floor of the storage building, so that under all circumstances they would be above high water in case of an accident or leakage into the basement. Such a contingency would put out of commission the transferring of grain from the storage to the boots, but would not affect the transshipment of grain from cars directly to the boots and thence to the shipping gallery.



Sectional Elevation of Pier 3

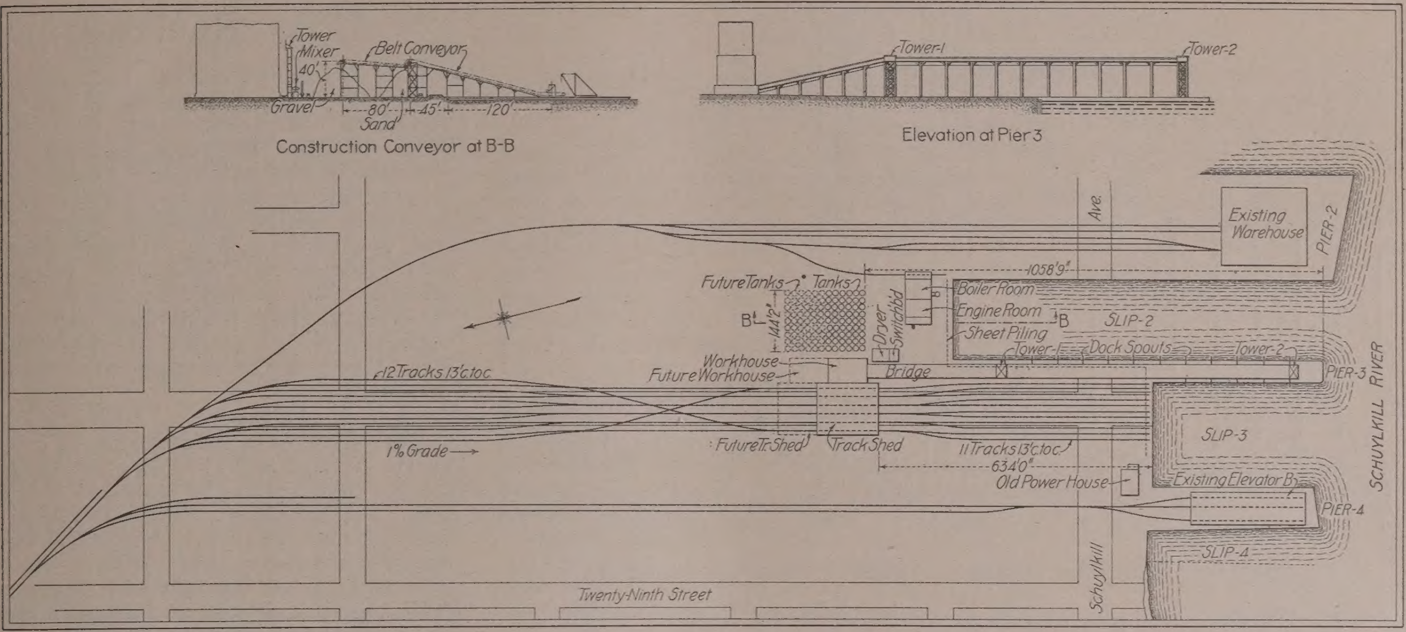
Installed in one of the pits under the car-track level is a six-drum Webster car puller operated in either direction by a 150-hp Allis-Chalmers motor and so arranged that each drum may be operated independently. The car puller is so adjusted that loaded cars can be placed by a locomotive on the eleven stub tracks beyond the trackshed toward the slip and on six tracks in the trackshed over the pits. After the cars have been unloaded they can be kicked north down a 1 per cent grade by the car puller onto twelve empty-car tracks and from there can be taken away by a locomotive. A retriever cable is attached to the hook on the end of the Roebling crucible-steel car-puller cable and run over a sheave at the pier end of the trackshed, thence back to a drum in the car-puller pit.

CONVEYOR GALLERY

In order to ship by vessels there is constructed a 4-belt conveyor gallery, 1,000 ft. long, extending south from the working house on pier 3. It is built of structural steel with 22-gage galvanized steel inclosing walls covered with five-ply Carey felt and gravel, and book-tile floor and roof are employed instead of concrete for the purpose of reducing the load. In each section of the gallery are four Webster conveyors of 15,000-bu. capacity per hour, equipped with belts furnished by the Gutta Percha Manufacturing Company, of New York. The conveyors in the second section are each equipped with two self-propelling trippers. Dock spouts are provided on each side of the gallery, spaced on 60-ft. centers, and are so arranged that grain may be shipped from any belt through any spout. All structural steel in the gallery and in other parts of the plant was furnished by the Riter-Conley Manufacturing Company from steel rolled by the Carnegie Steel Company.

STORAGE ANNEX

To the east of the working house and connected to it by a concrete tunnel and bridge is a storage annex consisting of fifty-four 13,000-bu. reinforced-concrete circular tanks with a basement and cupola. The tanks rest on a 4-ft. concrete mattress laid over a pier foundation. In the basement are three 36-in. shipping-conveyor belts, draw-off spouts and belt loaders for each tank and interspace. The circular storage tanks are 15 ft. inside diameter, 96 ft. high and have 7-in. walls. The forty interspaces have a capacity of about 3,300 bu. each.



Plan and Elevations of Grain Elevator of 1,000,000-Bushel Capacity at Girard Point, Pennsylvania

Over the tanks is a concrete floor for the 82 x 144-ft. cupola, in which are placed the storage belt conveyors, each provided with a two-pulley self-propelling, double-discharge tripper.

WATERPROOFING

Foundations for all buildings were waterproofed by the membrane method. Six piles of waterproof felt cemented together with pitch compound were applied by the American Asphalt & Rubber Company. The waterproofing was laid on a 9-in. slab of concrete deposited on top of the piles, between which earth was tamped even with their cutoff tops. The waterproof membrane was brought out beyond the area of the concrete slab a sufficient amount to allow for joining into the walls. As soon as the waterproof membrane was laid a protection layer of cement mortar ½ in. thick was placed on top. For the outside walls a 4-in. brick wall, laid in cement, was placed and capped with steel angles bolted to the concrete walls after the waterproof contractor had finished his work, which, according to specifications, was to be guaranteed for a period of ten years.

Under the foundation are 6,000 timber piles, 65 ft. long, driven to a gravel stratum on 2 ft. 3-in. centers both ways, with the exception that under the trackshed they are driven on 5-ft. centers. Tests were made on these piles, which were designed to carry 15 tons each, by loading three sets of four with pig iron up to 60 tons each. The settlement was only a fraction of an inch, although the loads were left in place several months.

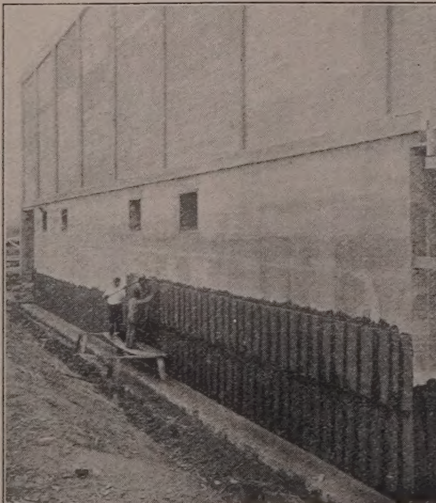
CONCRETE PIERS

The circular storage tanks rest on four concrete piers, 2½ ft. thick and 8 ft. high, placed in rectangular positions on the concrete mattress. These piers are in rows at right angles, 5½ ft. long in one direction and 8 ft. in the other. This permits space for the hoppers at the bottoms, which are laid on a slope of 10 to 12, with a 2-in. thickness of concrete over a filling of sand or cinders in which a small amount of cement is used.

The contact point between bins is 12 in. thick and extends 3 ft. either way from the tangent point. Steel hoop bands, varying from 1¾ x ⅜ in. at the bottom to 1 x 1⅛ in. at the top, are laid 12 in. center to center vertically in the center of the wall in two lengths, so as to have a lap of 3½ ft. Four 1-in. round vertical rods are provided for each tank on which the hollow screwjacks, patented by Folwell & Sinks, climb and carry the moving forms and platforms. Eight other vertical rods are also provided for the purpose of reinforcing the walls. These circular bin-moving forms are split up into sections so that in case of trouble with the forms surrounding one tank this tank may be left and the remainder of the structure allowed to go ahead a few feet. This permits building the whole area of the tank at one time without delay.

DIAGONAL BEAMS

The circular tanks in the working house are supported on diagonal concrete beams, 5 ft. deep and 2½ ft. wide, placed under the walls of the tank, which are assumed to transmit a uniformly distributed load directly to these beams. Hopper space is provided between the top of the beams and the girderless ceiling slab, which is suspended from the diagonal beams. The tanks are rigidly united at their adjacent tangent points by a 3-ft. vertical prism of concrete 2 ft. wide. Garners in the working house are constructed with reinforced-concrete rectangular walls, 10 in. thick, most of them being 16 ft. center to center.



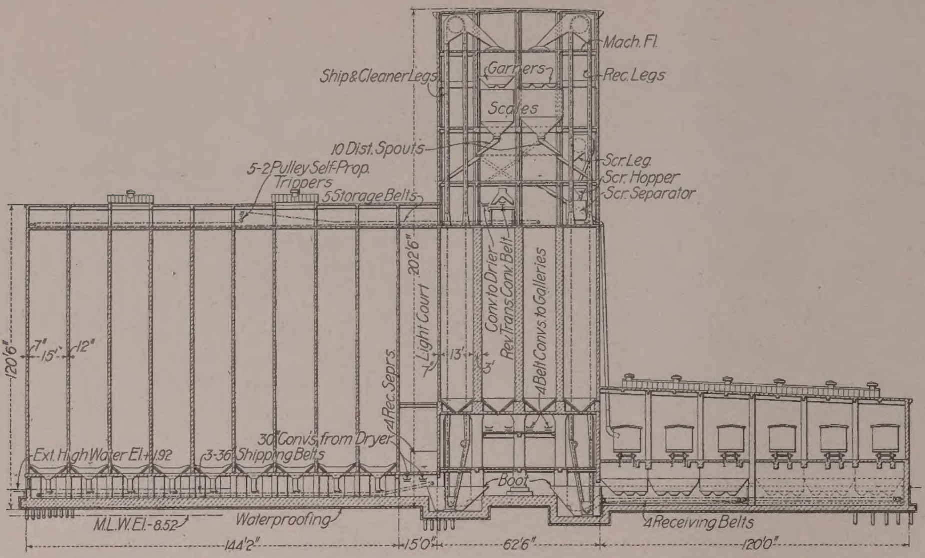
Applying Five-Ply Waterproofing

For measuring the temperature of the grain in the working-house and storage bins a Zeleny thermometer apparatus has been installed, with the galvanometer and switchboard placed in a convenient place in the foreman's office. Connections are made with thermoelectric couples, located in the center of every bin in the elevator and storage annex at an elevation of every 10 ft. By turning the switch to a contact corresponding to a certain couple it is possible to read accurately the temperature of the grain in any bin at any 10-ft. location. Supports are provided for suspending the pipe in the bins to resist the grain pressure on the pipes.

CONSTRUCTION PLANT

Concrete aggregates of gravel and sand were received by water and unloaded from the barges by a 40-ft. boom operating a McMyler grab bucket directly to a hopper over the end of a 20-in. belt conveyor carrying the material to stock piles north of the building site. A supplementary conveyor carried the gravel 80 ft. beyond the sand. Two ¾-yd. Smith mixers were set up in the open on platforms 18 ft. above ground between the stock piles and the building site.

One of the plants was opposite a 140-ft. tower serving the storage bins and delivering directly into the 1-yd. elevator bucket raised by a Clyde hoisting engine, while the concrete from the other plant was wheeled in buggies about 100 ft. over an elevated runway to the second tower, which elevates concrete to the forms for the working house. One-yard Lakewood cars, with a 3½-ft. gage, filled by hand at the stock piles in trains of four cars each, were pushed by hand to an elevating charging hopper in front of the mixing plants. Several tracks were laid under the stock-pile area so that the cars would always be near the material. Delivery of mixed concrete to the forms was by 6-cu. ft. Bullfrog buggies receiving their load from a 1-yd. storage hopper kept filled by the elevator bucket. A 28 x 100-ft. shed was filled with Lehigh cement, of which 30,000 bbl. were used, from a switch track on the east side



Longitudinal Elevation of Storage Bins, Working House and Trackshed

and emptied by cars running to the mixers over a narrow-gage track on the west side.

The average rate of rise with the movable forms for the annex storage bins was 5 ft. per twenty-four-hour day, the maximum rate being 10½ ft. The 340 jacks required for these tanks were operated by four men giving each jack one-quarter turn at a time when forms were being raised.

PERSONNEL

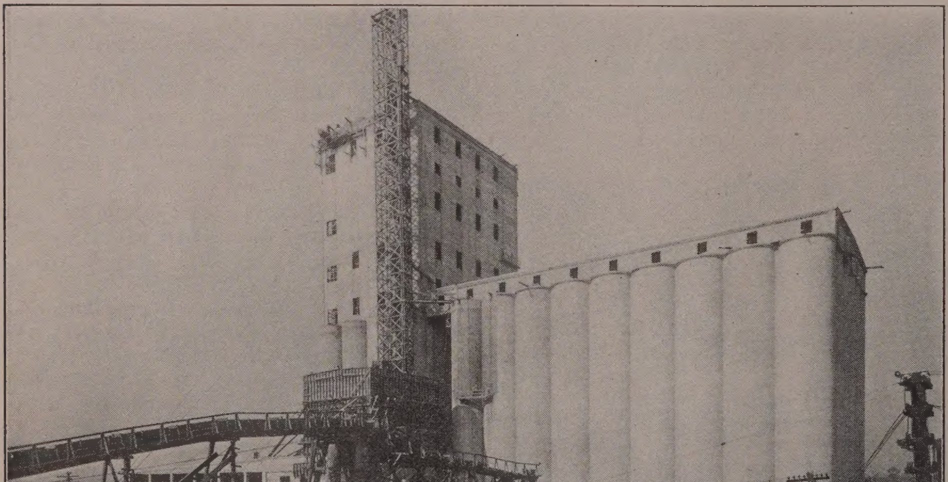
With the exception of the piling, which was driven by Armstrong & Latta, the construction was carried out by James Stewart & Company for the Girard Point Warehouse & Elevator Company, the terminal organization formed by the Pennsylvania Railroad Company to build and operate the elevator. Mr. W. H. Cookman is architect and Mr. A. C. Shand, chief engineer, directly in charge for the elevator company. For the contractors, who constructed the work in accordance with their own designs and specifications, Mr. R. H. Folwell is chief engineer, Mr. W. R. Sinks, general manager, and Mr. J. S. Johnson, superintendent.

Sheep for Cropping Grass on Canal Banks

LAST summer the Reclamation Service tried an experiment in cleaning Johnson grass from irrigation ditch banks in the Salt River Valley by allowing a flock of 150 sheep to graze along 5 miles of badly infested ditch. It is reported that very satisfactory results were obtained. In 1912 the cost of mechanical cleaning was $235.41 per mile. In 1913, with sheep and one cleaning with scrapers and shovels, the cost was $166.86, or a decrease of $68.55 per mile.

The expert in charge of the Arizona Experiment Station states that he believes two years of close cropping by sheep will eradicate the Johnson grass. A few of the farmers tried the same experiment on farm ditch banks with equally satisfactory results. Sheep thrive and fatten on this feed, and it was found that within three months many were read for market.

Other benefits were the compacting of the canal banks, elimination of gophers, and lessening of seepage.



Construction Plant for the Girard Point Grain Elevator

Book Reviews

"Electrolysis in Concrete" is the subject of Bulletin 18 published by the Bureau of Standards, Washington, D. C. The book, which comprises 137 pages, describes investigations relating to the nature and cause of the phenomena resulting from the passage of electric currents through concrete, possibilities of trouble from electrolysis in concrete structures under practical conditions, and protective measures. At the end of the book is a five-page summary containing the conclusions. (Washington, D. C., Department of Commerce, Bureau of Standards.)

"Fees for Electric, Magnetic and Photometric Testing" is the subject of a 23-page bulletin published by the Bureau of Standards. The pamphlet gives the fees established by the bureau for tests of electric, magnetic and photometric standards, measuring instruments and materials. It supersedes previous editions of Circular 6 and also the schedules of fees given in Circular 17, "Magnetic Testing"; Circular 20, "Testing of Electrical Measuring Instruments," and Circular 21, "Precision Measurements of Resistance and Electromotive Force." Future editions of these three circulars will be published without the list of fees. (Washington, D. C., Department of Commerce Bureau of Standards.)

Design and character of bridges involving an expenditure of millions of dollars are dealt with in a pamphlet entitled "The Æsthetic Treatment of City Bridges," by Henry Grattan Tyrrell, C.E. Attention is called to the effect of their appearance on the value of adjacent property. The most serious hindrance to artistic construction is considered to be a lack of sufficient funds. Some important principles of æsthetic design are enumerated, and there are a number of halftone engravings illustrating city and park bridges, most of them arch spans. (New York, The Civic Press. 15 cents.)

SEWER DESIGN. By H. N. Ogden, Professor of Sanitary Engineering, Cornell University. Cloth, 6 x 9 in.; 248 pages; 71 illustrations. New York, John Wiley & Sons, Inc. $2 net.

(Reviewed by George A. Johnson, Consulting Engineer, New York.)

This second edition is devoted exclusively to the design of sewerage systems, and is intended primarily for the instruction of students in sanitary engineering. It is quite a thorough digest of published articles on this general subject which have appeared in the various technical magazines, but the book is essentially a compilation discussed from the viewpoint of a teacher of engineering students, and it is doubtful if many really new ideas are conveyed by it to those engaged in designing such work.

The choice of title seems somewhat unfortunate, because only small space is given to the design of sewers. As before stated, the book deals almost exclusively with the design of sewerage systems, the preparation of maps, amounts of rainfall and sewage to be provided for, grades and sizes under varying conditions, and the use of flush tanks. In the description of these details the field of previously published knowledge is quite well covered, but very little is said as to actual design of sewer sections.

The author has apparently assumed that

all sewer pipe is made by burning, forgetting the already large and rapidly growing number of cases where very extensive use is made of cement and concrete pipe. In the matter of flush tanks, also, cuts are given of obsolete or obsolescent types, the more modern types being either omitted entirely or passed over hurriedly.

To the practising engineer one of the most useful portions of the book is a copy of the rules and regulations for the preparation and submission of plans for sewerage systems and sewage-disposal works prepared by the engineering department of the Department of Health of New York State. The State of New Jersey has also issued similar rules, and it is to be regretted that other States do not follow the excellent example thus set. The book is composed of 18 chapters comprising 248 pages. There are 24 good illustrations and 47 diagrams. It is a high-grade text-book in most respects.

SEEHAFENBAU. Volume 2, "Ausbau der Seehäfen." By F. W. Otto Schulze, Professor of Hydraulics at the Technical University, Danzig, Germany. Paper or Cloth, 7 x 9½ in.; 523 pages; 574 illustrations. Berlin, Wilhelm Ernst & Sohn, 24 and 25 Marks respectively.

This book on harbor construction is of the usually thorough type characteristic of German scientific literature. The author has collected the material from all parts of the world and has written his book somewhat on the lines of an encyclopedia. The nature of the book is, therefore, that of a collection of illustrations showing various types of structures, with explanatory text. It will, therefore, prove useful to engineers seeking information as to what has been accomplished in the field of harbor construction.

The last chapter of the book, dealing with the mechanical equipment of harbors, will be especially interesting to the American engineer. This section abounds in illustrations showing various devices in use for the loading and unloading of ships and barges.

The book is well written, easily read and so well illustrated by drawings that in many cases the text seems almost unnecessary; a noteworthy feature in the illustrations is that no photographs have been used. The author is to be complimented on the thoroughness with which the details of the structures he describes are illustrated.

Few theoretical matters are discussed. Only at the end of the first chapter, dealing with the calculation of sheet piling, bulkheads and pile foundations, are there any mathematical expressions. The book is divided into four parts—design and construction of structures outside the harbor (breakers, moles, etc.); lining of docks (sheet piling, bulkheads, dock walls, fenders and buoys); preparation of dock levels (roads, tracks, canals, warehouses, silos, elevators); and mechanical equipment.

A DRYDOCK TOWED 9200 MILES recently arrived safely in Surabaya, in the Dutch West Indies, where it was taken from Amsterdam by two tugs of 1000 and 1500 indicated horsepower respectively. The plan dimensions of the dock are 460 x 115 ft., and its lifting capacity is rated at 14,000 tons. Hawsers 18 in. in circumference were used for towing the dock, which carried a crew for manning the pump equipment and the four steam anchor winches.

Letters to the Editor

Estimating Quantities before Making Bids

SIR: It is of real importance to both owners and contractors that bids should be made upon a definite and known quantity of work to be done, as far as is reasonably possible. It is our belief that contractors for big engineering work would welcome a proper schedule of quantities to bid on as much as those who undertake smaller work. Where plans are incomplete or conditions are not definitely known this is usually done by contracts based upon unit prices, but where plans are complete and conditions are known it is assumed that quantities can be correctly computed by the contractors' estimators, and so lump-sum bids are asked for.

The fallacy in this assumption lies in the fact that it is not possible for a contractor's estimator, however expert he may be, to so thoroughly understand and read the plans of the architect or engineer in one week (the time usually allowed) as to scale them correctly. The architect or engineer generally spends some months working on his plans, and they are his own designs. By the time they leave his hands he is perfectly familiar with every line in them and their meaning is clear to him. The contractor's estimator in one week has to become as familiar with the plans as the architect or engineer. He cannot do it, and from this comes a large proportion of the mistakes in estimating which lead to irregular bids.

It is our belief that as many losing contracts are taken on incorrect quantities as on bad judgment in pricing. This is not to anyone's advantage, for the owner is always willing to pay a fair price for the work. He only wants to be sure what that price is, and the engineer, as a rule, would much rather have a contractor working for a profit than trying to save a loss.

ABERTHAW CONSTRUCTION COMPANY.
Boston.

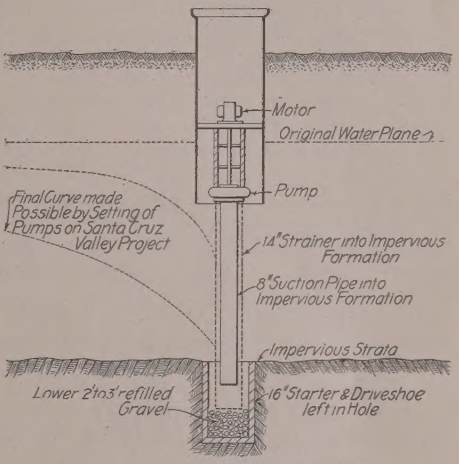
Irrigation of Santa Cruz Valley

SIR: The writer has read with interest the letters by Mr. Arthur L. Collins in your issue of Oct. 25, 1913, page 476, and Nov. 22, page 589, commenting on some of the essential features to be observed by engineers in planning systems for the recovery of subsurface waters, with particular reference to the Santa Cruz Valley system [see Engineering Record, Aug. 23, 1913, page 200].

The effective use of a submerged dam which will raise and hold at a given elevation the surface of the underflow below a line of wells across a valley, as adopted in the Santa Cruz Valley installation, must presuppose two conditions which do not always exist. These must be, first, the presence of an impervious formation extending across the valley at a depth below the surface which it would be practicable to utilize from the standpoint of cost, and, second, the presence of impervious formations forming the banks or walls of the underground channel which will confine the percolating waters to one course. Otherwise if the submerged dam were of any considerable height the underflow would follow along the line of least resistance and a portion, at least, would pass around the ends of the dam. In other words, the conditions would be similar to those produced by sealing up the discharge from a spring in order to raise the water for any purpose. The pressure head imposed would cause the water to seek and find another outlet.

If the cross-sectional area of the valley were such as to provide any material amount of water, the conditions would render a submerged dam founded upon impervious strata impracticable from the standpoint of cost, while with a small cross-sectional area, where impervious foundations and abutments would more likely be present, the available amount of underflow would be too small to justify the expense of a submerged dam in the great majority of cases.

In the Santa Cruz Valley installation the bottoms of the well strainers were set well down into the impervious, or practically impervious, material and the bottoms of the 8-in. suction pipes were placed within about 2 ft. of the bottoms of the strainers. This arrangement permits the entire amount of underground water which can reach the well to be drawn down to the impervious strata, where the latter are not below the practical suction lift. Of course where the impervious strata are located below the suction lift a certain area of water-bearing material will not be available for supplying the pumps.


Motor
Original Water Plane
Pump
Final Curve made Possible by Setting of Pumps on Santa Cruz Valley Project
14" Strainer into Impervious Formation
8" Suction Pipe into Impervious Formation
Impervious Strata
Lower 2' to 3' refilled Gravel
16" Starter & Driveshoe left in Hole

Pump and Water Planes

In the Santa Cruz Valley installation the location of the great majority of the pumps, with respect to the impervious strata, is well within the practical limits of suction lift. It is obvious, of course, that a certain percentage of the total underflow carried by the gravels between the wells cannot be recovered by pumping alone.

The writer agrees with Mr. Collins that the question of setting of the pumps is a very serious matter, and one which furnished more food for thought than all the other problems combined. A series of pumping tests on individual wells does not necessarily determine the location of the plane of draw-down for the entire system, and, in any event, results so obtained must be materially modified to conform to the actual conditions which will later develop. The writer knows of no method of predetermining closely the final location of the draw-down curve at the well, since the solution depends upon so many variables which it is not possible to foresee accurately.

This problem in the installation under discussion was particularly difficult, due mainly to three factors—the very spotted or variable nature of the water-bearing material in which occurred strata and lenses of clay; the non uniformity of depth of these strata; and the low pumping heads, where a small variation in the lift constituted a large percentage of the entire lift, which, of course, materially affected the capacity and efficiency of a single-speed pump. These variable conditions affecting the pumping head are usually partly overcome by using a belt-driven pump where the substitution of a pulley of different size will adjust the discharge of the pump to the capacity of the well, and also partly adjust the speed to the pumping head.

In the case under consideration, however, there were several vital reasons against the use of belted units. On account of the rather narrow limits of speed control, extra cost and lower efficiency, variable-speed motors were not considered desirable. For these reasons single-speed, direct-connected, motor-driven units were installed, the idea being to substitute later variable-size impellers in the various pumps, after the permanent location of the draw-down curve under full operating conditions had been reasonably well established. This would overcome in a large measure the difficulties which no amount of theorizing could eliminate. It was never the intention, nor was it expected, that the installation in question should recover practically the entire amount of underflow passing down the valley, although one statement in my previous article would very naturally convey this idea. Several prior water rights immediately below this installation—which in all probability would have to be respected by this junior appropriation—would preclude the possibility of taking the entire amount of the underflow even if it were practicable or possible to do so.

No mention has been made of the actual amount of water recovered by this system or the methods employed in the determination of the probable available water supply, since it is proposed to treat these subjects in a separate article.

M. C. Hinderlider,
Consulting and Supervising Engineer.
Denver, Colo.

Eccentric Riveted Joints

Sir: In checking some eccentric structural details recently a rather interesting paradoxical condition arose in that a joint was considerably strengthened by reducing the number of rivets. The accompanying sketch, while not a duplicate of any actual joint, illustrates the point.

Referring to the figure and disregarding for the present the dotted lines, the load P is applied at a distance $3a/2$ below the rivet A and at right angles to the rivet line AC. Evidently the maximum shear, V, on any one rivet will be on the rivet A and will equal the direct shear, V'—that is, the shear that would occur in the rivet were the load applied at Q, plus the shear V'' due to rotation about the center of gravity of the group of resisting rivets.

$$V = V' + V'' \text{ for rivet } A$$
$$V' = P/6$$

The rotating moment equals Pa, and since each rivet must act in proportion to its distance from the center of gravity of the group the resisting moment equals $aV''/5 + 9\,aV''/5 + 5\,aV''$.

Hence

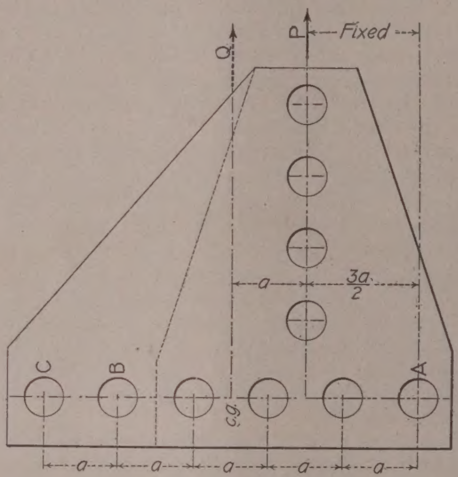
$$Pa = aV''/5 + 9aV''/5 + 5aV''$$
$$V'' = P/7.$$
$$V = P/6 + P/7 = 13P/42.$$

Now if the rivets B and C be omitted the joints will be as outlined by the dotted lines, and the center of gravity of the resisting rivets will move up until it falls on the line of direct pull. There will, therefore, be no shear due to rotation.

Hence

$$V = V' = P/4.$$

From the foregoing it is seen that the shear on the rivet A is approximately 24 per cent more in the joint with six rivets than in the one where only four rivets are used, and hence the first joint is 24 per cent less efficient than the second. If the line of rivets is extended downward until there are eleven rivets equally spaced in the line AC, the position of the load remaining fixed as shown in the sketch, the efficiency of the joint would only equal the one with four rivets.



Spacing of Rivets in Eccentric Joint

Of course joints with eccentric stresses should never be used unless absolutely necessary, but since they are at times unavoidable the writer believes that a series of tests on joints similar to the above, in order to determine how nearly theory and practice coincide, would be of considerable interest to structural engineers. If any such tests have already been made the writer would be glad to hear of them.

John C. Prior,
Department of Public Service.
Columbus, Ohio.

[On the assumption that the joint is frictionless, and disregarding the stiffness of the connected members, this method is theoretically correct and is used by competent bridge engineers. The errors due to the assumptions are both on the side of safety, and a rational analysis is thus secured.—Editor.]

Small-Cube Pavements of Monroe County

Sir: The article entitled "Small-Cube Pavements of Monroe County" in the Engineering Record of Dec. 6, 1913, page 624, might be amplified by a few remarks. The necessity for a strong foundation under all block pavements cannot be too strongly emphasized, especially with the advent of the heavy motor truck handling interurban business. Taking this fact for granted, is it advisable to lay a small-block pavement on anything but a concrete base and invite probable failure? The item of expense, of course, enters here, but in the last analysis a high first cost for an expensive foundation can be proved to be cheaper than the price of an excessive amount of maintenance.

Eliminate the use of a gravel bed and use sand in its stead. All large depressions in the surface of the original macadam pavement could be filled with gravel thoroughly rolled, or, better still, with concrete when the foundation is constructed of this material. A sand cushion not to exceed 1 in. in thickness should be spread over the entire area of the roadway and the blocks paved on it. The limiting depth of this cushion should be carefully observed or the advantage of the use of sand over that of gravel would be entirely lost.

On account of the small size of the blocks, they should be laid with close joints. The use of a sandy loam filler, with a subsequent application of tar surfacing or road oil over the entire surface, is one of the worst features of the pavements described in your article. This surfacing wears off rapidly, and then no protection whatever is afforded to the filler, which is soon carried away by traffic. Blocks begin to wear at the exposed edges, offering a point of easy attack for wheels and horses' hoofs. It is then a matter of only a short time before ruts and holes develop and the road goes to pieces.

To remedy these evil conditions employ a grout filler and eliminate the tar surfacing. This type of filler, mixed very wet and thin, once it has been applied to the work fills every joint completely up to the tops of the blocks. It is relatively permanent in character as compared to the sandy loam, which is soon dislodged from the joints. No protecting road oil is needed to hold the grout in place. Open joints and exposed edges will not soon develop to endanger the life of the pavement. The cost of maintenance with a tar surface is a maximum; with a grout filler it becomes a minimum.

If, after careful study, it is found that with the above recommendations the expense of laying a small-block pavement would be prohibitive, then discard this type of road and adopt another which will prove cheaper or more efficient at the same cost. It is a matter of small satisfaction to taxpayers and road users alike that their pavement has been laid at a small initial cost if its service to them is not of the best order.

S. Kronberg,
Bureau of Highways, Borough of Brooklyn.
Brooklyn, N. Y.

"Causes of Collapse of the Stark-Lyman Concrete Building in Cedar Rapids," an article embodying excerpts from a report of Mr. C. A. P. Turner, of Minneapolis, appearing in this journal Dec. 27, 1913, contained an error in the first paragraph under "Column Construction," beginning at the bottom of the second column on page 714. The paragraph should have read as follows:

"The lower tiers of columns are of the hooped and vertically reinforced type. This hooping is stopped on most columns as low as the fourth tier and on some lower than that, and from this point upward the columns are reinforced in the main with either four or eight rods vertically, and these are arranged with ties 12 in. or 15 in. apart, of from 5/16-in. to ⅜-in. diameter." The error occurred in misprinting a sentence from the report submitted by Mr. Turner's office.